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A Comparative Analysis between Paninian and Tesni`ere's Dependency Formalisms with Specific Reference to Annotating Karta

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Abstract

Paninian Dependency (PD) framework takes into consideration both the syntactic and semantic aspects whereas the Tesni`ere's Dependency (TD[1]) formalism is oriented more towards the semantic aspect for annotation. On one hand, the former is modeled upon the Paninian model of Sanskrit grammar. On the other hand, the latter is based on Tesni`ere's initial experimentation in French; later universalized with the advent of Natural Language Processing and inspires Universal Dependency (UD) formalism. Researchers like Kiparsky and Staal in 1969 and Bharati and others in 1995 have emphasized on the point that the PD formalism is accommodative of Indian languages drawing empirical observations from Hindi-Urdu. Therefore, it is hypothesized that PD will be more suitable and accommodative of Odia language as well. For that said purpose, a comparative analysis between the Paninian and Universal Dependency Formalisms has been conducted to figure out which formalism works better for Odia with special reference to the annotation of the karta 'k1' dependency relation.

Keywords: *Panini, Tesni`ere, Dependency Grammar Formalism, Universal Dependency, Odia, Karta, Dependency Linguistics, NLP, Karaka, Vibhakti.*

1. Introduction

One of the most salient objectives of dependency grammar is to create a tree-like structure for connecting to each and every word in a sentence. Dependency grammar is considered to have influenced some linguistic theories; specifically pertaining to semantics, for instance, semantic relations/cases/theta roles and related to the predicate. The former set of theories upholds the view where various arguments do connect to either their head or predicate whereas the latter deals with the relations where arguments directly connect to their predicates. Paninian Grammar is considered to be suitable for accommodating natural languages at the syntactic level as compared to models such as Phrase Structure[2] (PS) grammar [1] and Government & Binding (GB) theory [2]; for it encapsulates both syntactic and semantic information [3]. So far as the word order of Odia is concerned, it is relatively free [4, 5] and is head-final [5, 6].

2. Literature Survey

[1] Universal Dependency and Tesniere's Dependency formalisms are applied complementarily as UD is modeled on Tesniere's Dependency formalism
[2] Phrase Structure grammar is the opposite of dependency grammar so far as their frameworks are concerned

A. Paninian Grammatical Formalism

Several NLP researchers and computational linguists have further reported in their research that the PD is beneficial for Machine Translation (MT) [7] and Natural Language Processing (NLP) applications [8]. One of the most significant features of the Paninian Dependency structure is its capability to incorporate dependency relations that are long-distance between components in a sentence. Paninian Grammatical Formalism [8, 3, 9, 10, 11, 12, 13, 14] provides a syntactico-semantic level of linguistic knowledge and is based on two fundamental concepts. The first concept deals with the notion that syntactic-semantic relations and can be represented with karaka-vibhakti markers. The second one upholds the idea that Indian languages are morphologically or inflectionally rich [8, 13] and relatively free in terms of the word order [8, 15, 16]. Therefore, a dependency-based framework for parsing Indian languages is preferable and best suited. The formalism considers a sentence as a sequence of head and modifier relations; taking verb as the primary level head or the root of the sentence. The meaning in a language is encoded both in the words and the relationships between words. As the language is used for communication, each word contributes to the composition of larger meaning in a sentence playing two important roles. Each word signifies a concept and the combinatory role it plays in connecting each word with the others. The latter concept is expressed explicitly through some morphological markers as linguistic cues which can further be applied in extracting meaning. Inflectionally rich languages such as Sanskrit, Tamil, Telugu, Hindi, Odia have grammatical information embedded in their words. So far as Odia is concerned, there is only one reported research [12] in linguistics based on the Paninian model but it has nothing to do with dependency structures.

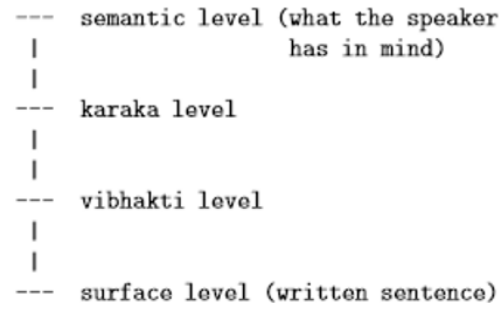


Figure 1. Levels of Representation in the Paninian Model (adapted from Bharati et al., 1996)

B. Tesni`ere's Grammatical Formalism

Tesni`ere's *´El´ements de Syntaxe Structurale* in 1959 [17] is considered to be the source of the modern dependency grammar [16, 18] and Universal Dependency Formalism. Tesni`ere's theory of dependency formalism is modeled broadly on the three pivotal concepts such as 'connexion' which means connection, 'jonction' translates into junction and 'translation' stands for transfer. The concept of 'connection' suggests to dependency relations and 'junction' is the relation between coordinated linguistic components. The concept of 'transfer' refers to the relation existing between a function word or other element which is potentially capable of changing the very syntactic category of a morphological or lexical component.

The frameworks as posited by Hellwig in the years 1986 and 2003 [19, 20], Hudson in the years 1984 and 1990 [21, 22] and Mel'ˇcuk in 1988 [23] explore the coordination dependency relationships. According to Sgall and others [24], Functional Generative Description (FGD) provides an analytical layer, as well as a

tecto-grammatical layer. As per Mel'ˇcuk [23], Meaning Text Theory (MTT) identifies two representations: surface and deep syntactic representations. Contrastingly, Tesni`ere in 1959 applies a single level representation of syntax called stemma, which encapsulates the relationships of junction and transfer including connection. According to Debusmann and others [25], the Extensible Dependency Grammar (XDG) is considered as a compromising position; for it provides multivariate dependency layers for representing linguistic components. This has a basic requirement though i.e. all layers have to share the same set of dependency nodes. This theory can be considered to be in contrast with theories such as FGD as explained above, where function words make their presence felt in the analytical layer, not at the level of tecto-grammar. There are several requirements of the frameworks of XDG and FGD which indicate to another caveat i.e. what exactly constitutes a node in a dependency representation. This can encapsulate some word forms which constitute *nucl´eus dissoci´e* or a dissociate nucleus as put forth by Tesni`ere in the year 1959. This can further encapsulate smaller units than the word forms, as put forth by Mel'ˇcuk [23] in his morphological dependency relationships. The framework of Word Grammar, as developed by Hudson [21, 22], provides both multiple headed constructions and cyclic graphs. Duchier and Debusmann, in 2001 [25] provided a framework called as Topological Dependency Grammar (TDG) according to which the linear order of the dependency construction has to be represented by a dependency construction which is linearly ordered. Lecerf in 1960 [27], Hays [28] and Marcus in the year 1965 [29] have discussed one of the constraints of projectivity in this connection which is directly in relation to the constraint of contiguity for the representations of constituents.

3. Research Methodology

A. Research Objectives

One of the salient objectives of the present research is to figure out the feasibility, suitability and accommodation of the Paninian Dependency formalism to Odia language. Drawing empirical observation from the Hindi-Urdu data, Kiparsky and Staal [3] and Bharati and others [8] have stated that PD is accommodative of Hindi-Urdu. Since PD formalism is modeled upon the syntactic-semantic frameworks (oriented more towards semantic aspects), it hypothesizes that it can be suitable to a free word-order language like Odia. It provides a comparative analysis between the PD and UD dependency formalisms with special reference to annotating 'karta-k1' dependency relations.

B. Method of Data Collection and Analysis

So far as the method of data collection is concerned, a corpus of 1k Odia sentence of general domain has been taken into consideration for this research. The data has been taken from the ILCI Project group publicly accessible from the DST website on TDIL. So far as the method of data annotation is concerned at the parts of speech (POS) level, Bureau of Indian Standards (BIS) schema developed by the Indian Languages Corpora Initiative (ILCI) Project Consortium has been considered. The ILCI Ann App has been applied for the annotation of POS categories. As far as the annotation at the level of chunk is concerned, the tagset [30] developed by the Indian Institute of Information Technology (IIIT), Hyderabad has been taken into account. For annotating dependency relations, Paninian model is considered as propounded, developed and applied by the IIIT Hyderabad annotation convention [7, 29, 31]. So far as the UD is concerned the same data of Odia PG counterpart has

been annotated as per the standards developed by the Universal Dependency [3] formalism for POS, Chunk and dependency relations. For the annotation of the respective data Webanno[4] annotation tool has been applied.

4. A Comparative Analysis of PD and UD

The following tabulated representation (see table 1) demonstrates the fact that PD has annotation labels of five in numbers for the dependency annotation of a subject. If we map the labels of PD with UD, we get only one label of 'nsubj' which stands for the nominal subject or karta. Another annotation label which may be considered under the subject category is 'nsubjpass' which stands for the passive subject (refer to 3 sub-section). Since the passive subject is the direct object in an active sentence. Therefore, the 'nsubjpass' can be considered in relation to the dependency label of a direct object.

Table 1. A comparative mapping of PD and UD labels for subject

PD	LABELS WITH GLOSS	UD	LABELS WITH GLOSS
karta	subject/agent/doer 'k1'	subject/agent/doer	Nominal subject 'nsubj'
Vidheya karta	Noun complement 'k1s'		
Prayojya karta	Causer 'pk1'		
Prayojaka karta	Causee 'jk1'		
Madhyasta karta	Mediator 'mk1'		

A. Dependency Relation[5] k1 ('Karta' doer/agent/subject)

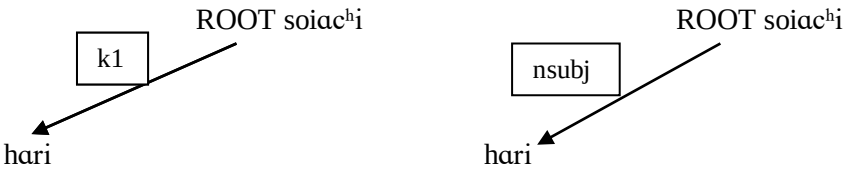
Karta is that semantic component of the sentence which accomplishes an action denoted by the verb called as the 'kriya' in the Paninian tradition. According to the framework, there are two types of karta viz. primary and secondary. The former focuses light on the volitionality aspect ingrained in the subject while the latter emphasizes on the non-volitionality part.

There are some circumstances or conditions under which the karta can have its occurrence in the sentence. They are as follows.

1. When the verb refers to a given action and the karta (k1) is the performer of that action. Here, karta 'Hari' is the argument of an intransitive verb 'sleep'.

K1-1: hɑri soiɑcʰi
Hari-3MSG.NOM sleep-3SG.PRS.PRF
'Hari has sleept'

[3] https://universaldependencies.org/
[4] https://webanno.sfs.uni-tuebingen.de/
[5] The trees on the left-hand side suggests PD while the right-hand side refers to UD

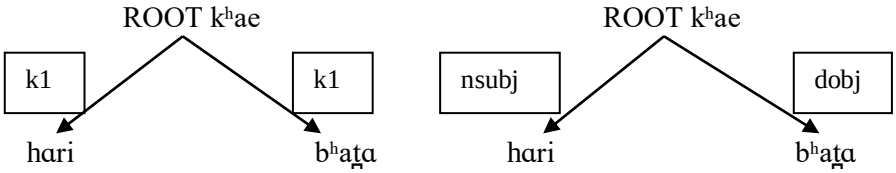


Syntactic Cues:
There are two salient features based on the syntax to figure out the karta in Odia.

i. Generally, karta takes a nominative case which is realized as a zero marker or covert case in Odia. It is also true to many of the Indian languages.
ii. The finite or active verb in Odia usually agrees with the karta in person and number; not in gender[6].

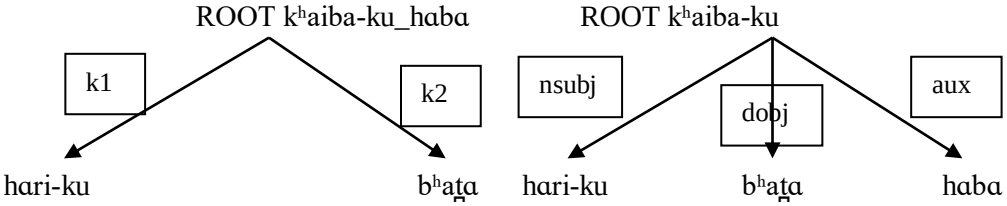
It is noteworthy to mention here that including karta, there are other karaka dependency relations that can occur without a zero vibhakti or case marker. However, the circumstances or conditions under which some given karaka relations can take place with a fixed vibhakti marker may not always have its bearing on syntax. Therefore, one also needs to take into consideration the other aspects such as context and semantic properties including syntactic features for the said purpose.

K1-2: hɑri bʰaṯɑ kʰae
Hari-3MSG.NOM rice-ACC eat-3SG.PRS.IMP
'Hari eats rice'



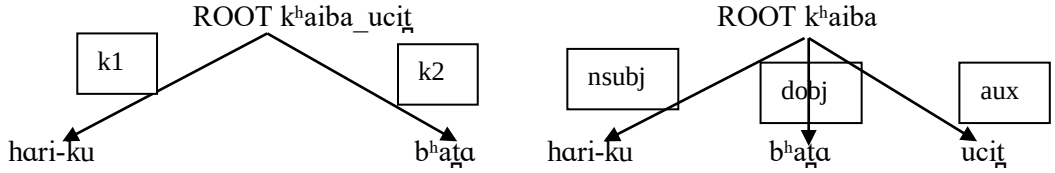
2. Moreover, 'karta' in Odia can have the conventional dative vibhakti markers for representing the non/nominative case constructions. Here, the conventional case marker 'ku' for dative in Odia is used to refer to the nominative case construction.

K1-3: hɑri-ku bʰaṯɑ kʰaiba-ku hɑbɑ
Hari-3MSG.NOM rice-ACC eat-INF be-3SG.FUT.IMP
'Hari has to eat rice'



K1-4: hɑri-ku bʰaṯɑ kʰaiba uciṯ
Hari-3MSG.NOM rice-ACC eat-INF should
'Hari should eat rice'

[6] Odia has morphological gender, not the grammatical one.

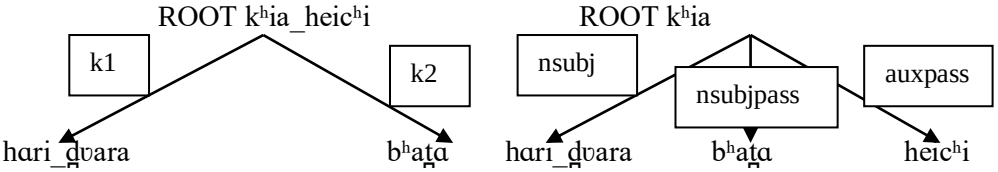


Syntactic Cues:
For the identification of the karta in the aforementioned constructions, below mentioned are some of the rules (see table 2 below) as to which vibhakti/case/postposition markers should go with TAM (tense, aspect and mood) features.

Table 2: TAM identification markers for subject

Vibhakti markers	TAM verbal markers	TAM Relation
Zero or ku	e/ɑ/anti	PRS/PAST/FUT
ku	barɑ ɑcʰi	compulsive
ku	bɑ uciṭ	imperative or prescriptive

3 Passive constructions usually bear markers such as ‘re’ and ‘d̪ʊara’ without the physical presence of a conventional subject.
K1-5: hɑri d̪ʊara bʰat̪ɑ kʰia heicʰi
Hari by rice-3SG.ACC eat-PASS be-3SG.PRS.PFV
‘Rice is eaten by Hari’



Syntactic cues:

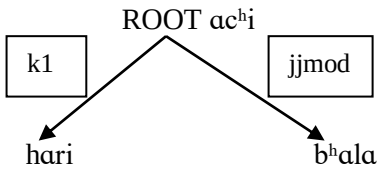
i. A noun followed by the postpositional or vibhakti markers ‘re’ and ‘d̪ʊara’ in Odia.
ii. The verbs having passive TAM markers would be a karta.

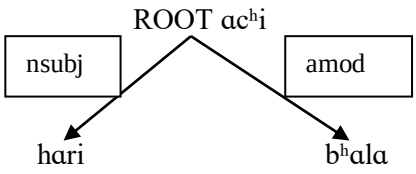
4. karta with a genitive vibhakti marker
Subjects with genitive markers in Odia are included in this category.

K1-6: hɑri-rɑ kɑhibarɑ ɑcʰi ki asɑnt̪a kɑli megʰua hebɑ
Hari-GEN say-INF be-3SG.PRSIMP that tomorrow overcast be-3SG.FUT.IMP
‘Hari says that it will be cloudy tomorrow’

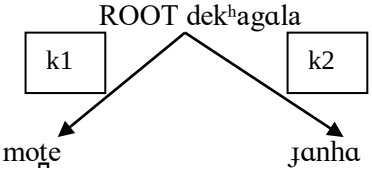
In the aforementioned kind of cases, the verbs are gerundive in nature and typically end with an infinitive marker such as ‘ba’ or ‘barɑ’.

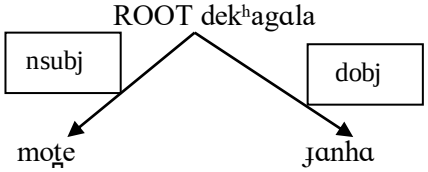
5. Some more instances that are considered to be noteworthy to mention here are as follows.
K1-7: hɑri bʰɑlɑ ɑcʰi
Hari-3MSG.NOM fine be-3SG.PRS.IMP
‘Hari is fine’





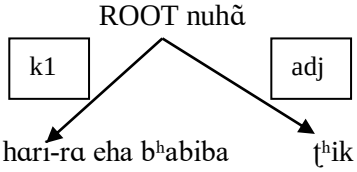
K1-8: moⱪe ɟɑnhɑ dekʰɑgɑlɑ
I-1SG.NOM moon-3SG.ACC look-3SG.PST.IMP
'I saw the moon'

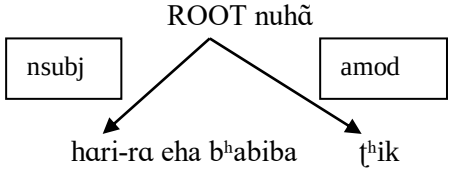




In the instance above (k1-7) in case of a stative verb, where the state of a thing or person is expressed, the state of Hari is mentioned. Therefore, Hari is the karta or subject of the sentence. Analogously, in accusative verbs such as 'ⱪekʰa ɟiba', 'suɳa ɟiba', the subject has to be marked as the karta and not the noun in the canonical subject position in Odia. The doer of the activity in an accusative verb 'ⱪekʰa ɟiba' is quite different from the accusative verb 'ⱪekʰiba'. Hence, it can be deduced from the aforementioned instance k1-8 that the karta of the sentence is the 'moon' and not 'me'.

6. Clausal Karta:
A clausal component of a sentence can also be a karta which is called a clausal karta.
K1-9: hɑri-rɑ eha bʰabiba tʰik nuhɑ̃
Hari-GEN this-DEM think-INF good be-3SG.NEG
'This thinking of Hari is not good'





In the above-instantiated example, the clausal component 'hɑri-rɑ eha bʰabiba' of the sentence headed by the gerundive construction is the karta whereas the root of the sentence is the finite verb embedded in the negative expression 'nuhɑ̃'. Therefore, the 'k1' label for the clause is to be annotated as the non-finite verb of the given clause.
Salient features for identifying karta:

- Generally, verbs agree with the nominal features, in an active sentence, of the karta. The finite verb is having an agreement with the nominal features of the karta 'Hari'.

e.g. hɑri mɑcʰɑ kʰɑuɑcʰi
Hari-3MSG.NOM fish eat-3.SG.PRS.PROG
'Hari is eating the fish'.

- There is always at least one karta in a sentence. Here, Hari is the single karta in the sentence.

e.g. hɑri gʰɑrɑ-ku ɟai pʰeri asila
Hari-3MSG.NOM home-LOC CONV return come-3.SG.PST.PRF
'Hari came back after visiting his home'

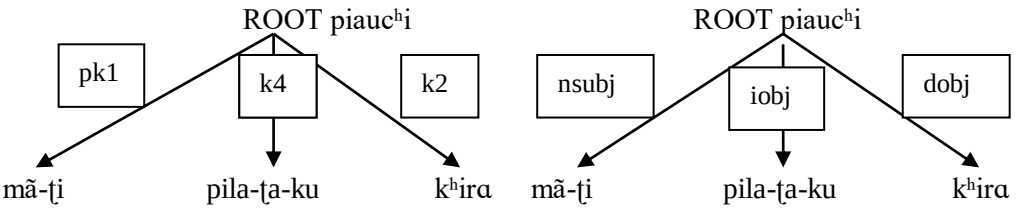
- Generally, all personal pronouns (1st, 2nd and 3rd) in Odia in a nominative case are karta having dependency label k1.

e.g. ʈume kʰaɖjɑ kʰauɑcʰɑ
you-2SG.NOM food-ACC eat-2SG.PRS.PROG
'You are eating food'

B. Dependency Relation pk1, jk1 and mk1 (causee, causer and mediator-causer)
Causative constructions in Indian languages are caused by the morphological processes of inflection and derivation. Odia is not a different case with regard to causatives. In the Paninian formalism, both the causer and the cause are marked.

i. Pk1 (prayojaka karta 'causer')

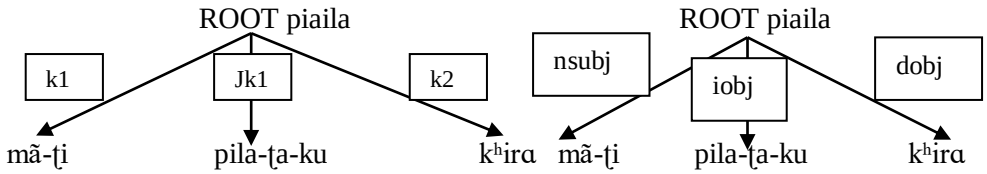
mã-ʈi pila-ʈa-ku kʰirɑ piaucʰi
mother-3MSG.CLF.NOM child-CLF-DAT milk-ACC drink-3SG.PRS.PROG.CAUS
'The mother is feeding milk to the child'



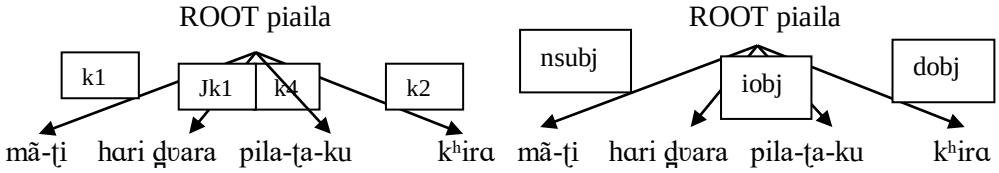
Syntactic cues:
Since the causer or pk1 behaves syntactically, the subject or k1 of the sentence; therefore, all the syntactic features used for the identification of k1 are also applicable for this. However, there are a few differences between the karta and the prayojaka karta which can be observed from the verbal morphological causative features or suffixes.

ii. jk1 (prayojya karta 'causee')
In the Paninian formalism, the prayojya karta 'causee' is annotated as jk1.

Jk1-1 mã-ʈi **pila-ʈa-ku** kʰirɑ piaila
Mother-3MSG.CLF.NOM child-CLF.DAT milk-ACC drink-3SG.PST.PFV.CAUS
'Mother made the child drink the milk'



Jk1-2 mã-ʈi **hɑri** ɖʊara pila-ʈa-ku kʰirɑ piaila
Mother-3MSG.CLF.NOM Hari by child-CLF.DAT milk-ACC drink-3SG.PST.PFV.CAUS
'mother ordered Hari to drink the milk'

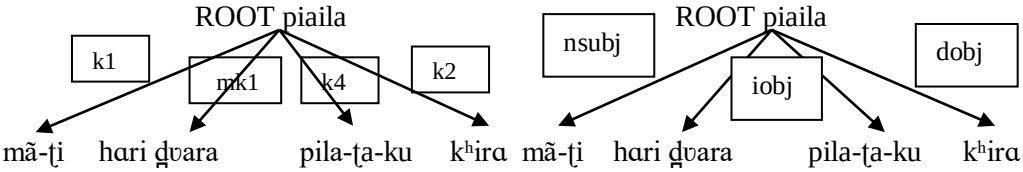


Syntactic Cues:
Syntactically, 'ku' and 'ɖʊara' are the morphological markers for the identification of prayojya karta or 'causee'. However, the selection of 'ku' and 'ɖʊara' depends on the type of verb. Therefore, it can be stated that there is no any definite syntactic features for its identification. In this case, the determining factors for the consideration are the verbs and their semantics.

iii. mk1 (madhyastha karta 'mediator causer')

In causatives there needs to be a causer and one causee; although in a sentence there may be more than one causer. In these kinds of construction, the causer number second can be called a mediator or a causee-causer. In the Paninian formalism, this dependency relationship is labelled as mk1. Furthermore, there would be more than one mediator. In case, if there is more than one mediator all are to be annotated as mk1.

Mk1-1: mã-ʈi **hɑri** ɖʊara pila-ʈa-ku kʰirɑ piaila
Mother-3MSG.CLF.NOM Hari by child-CLF.DAT milk-ACC drink-3SG.PST.PFV.CAUS
'mother made the child drink milk through Hari'



Mk1-2: mã-ʈi **hɑri ɖʊara** ramɑ sɑhɑ pila-ʈa-ku kʰirɑ pieila

Mother-3MSG.CLF.NOM Hari by Ram with child-CLF.DAT milk-ACC drink-3SG.PST.PFV.CAUS
'Mother made the child drink milk by Hari with the help of Ram'

Syntactic Cues:
The vibhakti markers for mk1 dependency relationship are either 'ɖʊara' or 'ku'. In case if there is more than one mediator then the first one will take 'ɖʊara' marker and the second one will take the 'ku' vibhakti marker in Odia. Moreover, one needs to keep in mind that the causer-causee dependency relationship depends and is modeled upon the verb morphology and not other syntactic processes.

C. k1s (karta samadhikarana 'nominal complement')
The complements of nouns are marked as 'k1s'. The term 'samadhikarana karta' refers to 'having the same locus' as that of the karta. Therefore, it is indispensable that a sentence must have a karta as the prerequisite feature.

K1s-1: **hɑri** sunɖarɑ ɑʈe
Hari-3MSG.NOM handsome be-3SG.PRS.IMP

'Hari is handsome'

5. Conclusion

There is only one annotation label for the dependency relation of the karta i.e. nsubj according to the Universal Dependency formalism whereas Paninian Dependency framework provides a range of annotation labels for annotating the same having the label 'k1' (mk1, jk1, pk1, k1, k1s). This suggests to the fact that PD is governed by the syntactic-semantic principles; oriented more towards the semantics as it does formulate a karaka-vibhakti relation for the identification of case relations. On the other hand, the UD is governed by the syntactic principles; less-oriented towards the semantic aspect.

The present research specifically focuses on the feasibility of the application of Paninian Grammatical Formalism in Odia language. For that said purpose, I have provided a comparative analysis of PD and UD frameworks annotating the 'karta-k1' dependency relations in Odia. It can now be observed from the aforementioned empirical linguistic data that the former dependency theory is better accommodative of Odia at the levels of syntax and semantics.

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