

Implementation of a Part-of-Speech Ontology: Morphemic Units of Bantu languages

**Disciplinary field of study:
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Abstract: In a previous article (Faaß et al, 2012), a first attempt was made at documenting and encoding morphemic units of two South African Bantu languages, i.e. Northern Sotho and Zulu, with the aim of describing and storing the morphemic units of these two languages in a single relational database, structured as a hierarchical ontology. As a follow-up, the current article describes the implementation of our part-of-speech ontology. We give a detailed description of the morphemes and categories contained in the database, highlighting the need and reasons for a flexible ontology which will provide for both language specific and general linguistic information. By giving a detailed account of the methodology for the population of the database, we provide linguists from other Bantu languages with a road map for extending the database to also include their languages of specialization.

Keywords: part-of-speech ontology, morphemic categories, Bantu morphology, Northern Sotho, Zulu

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1 Introduction and Contextualization

In Faaß et al (2012) a first attempt was made at documenting and encoding morphemic units of two South African Bantu languages, i.e. Northern Sotho and Zulu, with the aim of describing and storing the morphemic units of these two languages in a single relational database. We argued that it was necessary to describe types of units on several sub-word levels for optimal success with tagging of morphemes.

We furthermore illustrated that it was not only feasible to store and represent the morphemic units of these two languages in a single ontology, but that such an ontology could make provision for all Bantu languages. Therefore, the design of the ontology is such that it can accommodate morphemes which are common to all Bantu languages, but also those morphemes which are language specific.

A hierarchy of morpheme categories was built which is valid for both languages, but which in some cases necessitated some adaptation of the categories traditionally distinguished in Northern Sotho and Zulu. The disjunctive versus the conjunctive writing systems of the two languages have no influence on the structuring of the hierarchy. However, morpho-syntactic differences are to be taken into account since instances do occur where, for example, free morphemes in one language are bound in the other. In cases such as these, two categories need to be distinguished.

The current article aims at describing the implementation of our part-of-speech ontology. In section two, a full specification of all morphemic categories of the two languages as represented in the ontology is presented, assuming that the inventory of all categories is complete. Section three describes the design and the implementation of the ontology database and its graphical user interface which is referred to as “front end” in this article. A detailed description of the ways users can browse and edit the data (front end) is also provided in this section. A roadmap for the extension of the database to other Bantu languages is also exemplified in this section. Finally, section four concludes the article and points to future work.

The overall goal of the article is to provide a road map for future users, should they wish to apply the ontology to other Bantu languages for purposes of cross-linguistic morphological annotation of texts, as a database for the development of morphological analysers/generators and/or as a supplement to lexicographic data collections.

Our project started from the assumption that despite different surface structures, the Nguni and Sotho languages (and to a large extent many other Bantu languages) distinguish the same categories of morphemes, and that those morphemes appear in the same order in many cases. Taljard and Bosch (2006) demonstrated that this assumption is indeed true for Zulu and Northern Sotho. Faaß et al. (2012) showed that these categories fall into hierarchical classes, where each class on a lower level inherits the properties of the class above it, thus making an ontology an extremely suitable repository for representation of Bantu morpheme categories. We do not claim this to be a novel idea - Khoury et al. (2008) have introduced a similar implementation for English.

Working from a synchronic perspective, we aim at a comprehensive, cross-linguistic and ordered overview of the morpheme categories occurring (not only) in the official Bantu languages of South Africa. There are three main challenges for such a task: First, we need to internally standardize the

names of categories, as in traditional grammatical descriptions the two language groups quite often use different terms for identical categories (see section 2.1). Secondly, in some cases (see section 2.2), the same semantic phenomenon appearing in both languages is realised on the surface as two different morpho-syntactic categories, which implies that language-specific categories cannot be avoided. Lastly, the design and implementation of the database (in MySQL) should be such that it is accessible via the web to any interested fellow scholar. The database should be extendable so that data from Bantu languages in various degrees of relatedness can be added.

Concerning the establishment of an accessible database, it can be reported that such a database has already been set up (see Faaß et al., 2012). It contains a full inventory of all closed class items belonging to the two languages in question, and can be queried (<https://www.uni-hildesheim.de/iwist-cl/projects/ontology/>). In this article we will focus on the challenges of a cross-linguistic view on morpheme categories and we will describe how the interested user can access and browse our data. Lastly, we contextualize our work within the larger framework of e-lexicography.

2 Categories and morphemes of the two languages

In our ontology, no distinction is made between open and closed classes because such categorizations are more applicable to surface word forms than to morpheme categories. The ontology however contains all morphemes belonging to closed class parts of speech (for example, all of the morphemes and their allomorphs forming subject concords of Northern Sotho). Additionally, a number of roots and stems are contained which are open class parts of speech (e.g. ideophones) or which form the basis of open class parts of speech (e.g. common noun roots). We aim at filling this part of the inventory by using corpus data as part of an ongoing process.

Both languages treated so far distinguish noun class dependent and noun class independent categories. Both of these contain free and bound roots and word formation affixes. Word formation usually distinguishes compounding (which is not relevant for morpheme categorization and thus not contained in the database), derivation and inflection. The latter two processes are accomplished by adding prefixes and/or suffixes. Figure 1 shows the hierarchy levels 1 to 4 of the current ontology.

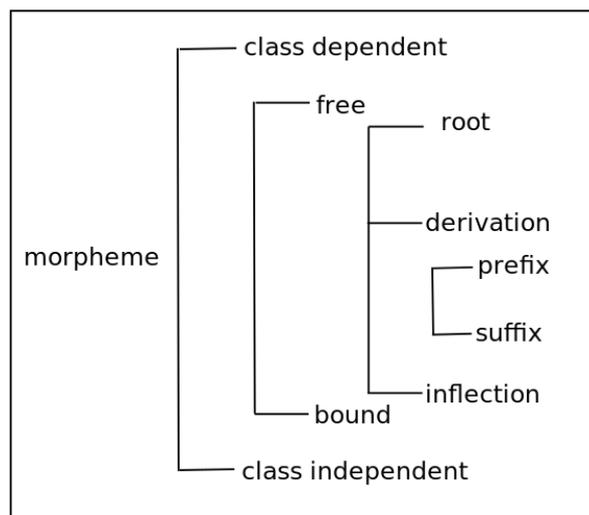


Figure 1: Levels 1 to 4 of the ontology

It should be noted that we do not recognize infixes as a morphemic category in either of the two languages. As Kosch (2006:9) points out, true infixes are hard to find in the Bantu languages and are

largely a matter of definition. Possible infixes, such as the passive *w-* in Northern Sotho which is said to be inserted into the past tense suffix *-ile* (forming *-ilwe*), can easily also be subsumed under the term suffix, as the morpheme “verbal ending” *e* can be assumed to have been added after the inflectional passive had been formed. We hence assume that derivational or inflectional affixes are added to incomplete word forms, which do not contain a final morpheme – the final verbal or nominal morpheme is only added after the derivation process has been completed.

For each of the morphological items added to the database, we assign the attributes “person” and “number” wherever appropriate. The attribute “person” distinguishes “first”, “second” and “third” (which is represented by the noun classes).

Concerning a naming convention for our morpheme categories, we need to follow the traditional naming conventions of Bantu linguists so that others will not find it difficult to make use of our system; on the other hand, we deem it necessary to follow the recommendations of the former Expert Advisory Group on Linguistic Engineering Standards (EAGLES¹), proposing *non-ambiguity*, *compactness*, *readability* and *processability* (Leech and Wilson, 1999:59) of the names we choose.

Levels 5 to 7 of the ontology already describe some language specific morphemic categories; for Northern Sotho and Zulu there are nominal, verbal, qualificative and a number of other roots, e.g. ideophones (IDEO), adverbs (ADV), conjunctions (CONJ), interrogatives (INT) and the three categories solely used for Northern Sotho, i.e. hortative and interrogative particles (PART_Hort and PART_Int), and class independent question words (QUE_nil). The bound roots, however, all begin with the name “ROOT” in order to distinguish them from the affixes. Figure 2 shows a complete tree for a common noun root as an exemplification.

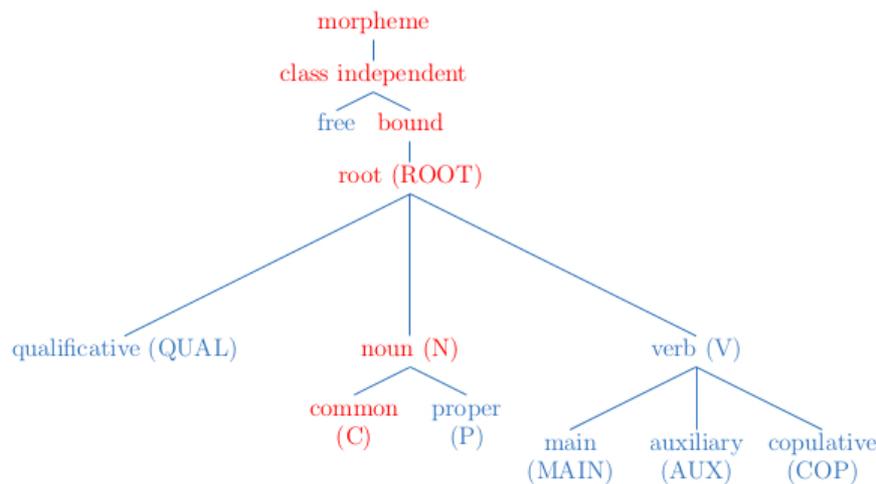


Figure 2: The path through the ontology to the common noun root

2.1 Deviation from traditional grammars

Any endeavour to describe morphological categories of Northern Sotho and Zulu (or of any language, for that matter) needs to take into consideration that existing grammatical descriptions are embedded in specific linguistic traditions and conventions. These descriptions are often very finely granulated

1 <http://www.ilc.cnr.it/EAGLES96/browse.html>

and a lesser degree of granularity is sometimes necessary for a computational application. Some grammatical distinctions, though linguistically sound, are often not relevant for the purpose of our ontology. One such a case is the distinction which is made between copulative particles (respectively prefixes) and subject concords in Northern Sotho, cf. Louwrens (1991). In essence, copulative particles are subject concords which function as fully-fledged copulative verbs, although they appear without any copulative verb stem. Subject concords typically appear as verbal prefixes of verb stems (cf. (2) below), and based on these distributional and syntactic differences, a distinction is drawn between these two categories – subject concords with a copulative function are categorised as particles in grammatical descriptions of Northern Sotho and thus regarded as linguistic words, whereas subject concords are regarded as agreement morphemes. Compare the following examples (for part of speech annotation, the tags described in Taljard et al. (2008) are used):

- (1) *Basadi* *ba* *bohlale*
 N02 PartCop N014
 ‘Women are clever’
- (2) *Basadi* *ba* *bala* *kuranta*
 N02 CS02 VS N09
 ‘Women read the paper’

Despite these differences, in our ontology we categorize both the so-called copulative particles and the subject concords as class dependent agreement morphemes, partly because the category ‘particle’ is a rather problematic one when viewed against the background of generally accepted linguistic principles for part-of-speech distinction, and secondly, because what is currently categorized as copulative particles developed from fully-fledged copulative verbs from which the copulative verb stem has been dropped.

Another example of deviation from traditional grammars is the case of the locative noun classes. In Northern Sotho for example, 5 different locative noun classes are distinguished, typically classes 16 (*fa-*), 17 (*go-*), 18 (*mo-*), and two unnumbered classes with prefixes *N*⁻² and *ga-* respectively; in Zulu, the locative classes are 16 (*pha-*), 17 (*ku-*) and 18 (*mu-*). This distinction between the classes is mostly a morphological one, based on the different class prefixes; however, these prefixes do not carry any specific semantic implications in these two languages. As a result of this process of semantic bleaching, all classes mainly use one set of concords, namely that of class 17. In our ontology therefore, we do not make provision for separate locative classes, but assign all locative nouns and morphemes related to these classes to the category LOC, as was already suggested by Taljard et al. (2008).

We are furthermore aware of the fact that the so-called absolute or emphatic pronouns in both Northern Sotho and Zulu are not monomorphemic; in most cases they consist of a concordial element, plus a root *o-*, followed by a suffixal morpheme *-na*, e.g. *s-o-na* (class 7), *b-o-na* (class 2). However, there is no consistency with regard to the morphological decomposition of pronouns in either of these two languages, especially with regard to the first person singular (NSO *na*, ZUL *mina*) and the second person singular *wena*. It was therefore decided to enter all pronouns as class-dependent, but free roots. A similar approach is followed by Hendrikse and Poulos (2012:260) when they categorise pronouns in Bantu languages as simple, i.e. atomic schematic structures which appear in the lexicon as free morphemes.

In conclusion to the discussion on deviation from traditional grammars, we pay attention to the naming conventions *root* vs *stem* in descriptions of Bantu languages, with particular reference to Zulu and Northern Sotho. Kosch (2006:10-11) summarises the naming convention succinctly by explaining that the possible reason for the indiscriminate use of the term *stem* when *root* is actually meant, is the perpetuation of a descriptive tradition in Bantu language grammars over many years. Doke (1980:286-287), who played a leading role in the earlier linguistic development of Bantu languages in

2 We make use of the placeholder *N-* to describe nasals such as *m-* or *n-* appearing as class 9 prefixes.

South Africa, states that: “The distinction between roots and stems is more or less arbitrary, and one employed for convenience.”

For the purposes of our ontology we follow a root morphology approach whereby we distinguish between two types of morphemes, namely roots (as free or bound morphemes) and affixes (as prefixes and suffixes). The root is regarded to be the constant core element of a word in the Bantu languages, carrying the basic meaning, while the remainder of the word or word form represents inflection and derivation (Hurskainen, 1997:631). Therefore, in the case of nouns we may distinguish between noun roots and verb roots (in the case of deverbative nouns), as shown in (3).

Zulu

- (3) a. *umuntu*
umu- *-ntu*
 PrefClass_01 ROOT_NC
 ‘person’
- b. *isinkwana*
isi- *-nkwa-* *-ana*
 PrefClass_07 ROOT_NC SuffDim
 ‘small bread’
- c. *imibono*
imi- *-bon-* *-o*
 PrefClass_04 ROOT_VMAIN SuffNEnd
 ‘see’
 ‘idea’
- d. *umfundisi*
um- *-fund-* *-is* *-i*
 PrefClass_01 ROOT_VMAIN SuffExtCause SuffNEnd
 ‘learn, study’
 ‘teacher’

2.2 Descriptive differences between languages

First, descriptive differences between languages are often the result of adherence to different descriptive frameworks, rather than of fundamental linguistic differences. This is particularly evident when a comparison between Northern Sotho and Zulu is made. Northern Sotho grammatical descriptions mostly adhere to a structuralist framework as advocated by Van Wyk, whereas those of Zulu are mainly done within the functional approach of Doke, cf. Kosch (1993:32). These different theoretical frameworks lead to similar grammatical phenomena being categorised differently in the two languages, although they are fundamentally the same. One such an example is categorization of locative nouns, that is nouns belonging to the so-called locative classes 16, 17 and 18. Within the structuralist approach, these are categorized as belonging to the word class ‘noun’ in Northern Sotho, based on their morphological structure, i.e. class prefix + root, e.g. NSO *fa-se*, but in terms of their function, Doke classifies them as adverbs in Zulu. Critical consideration is therefore required when items such as these are assigned to the categories in the database: should they be assigned to different categories based on the way in which they are described in the literature, or should some compromise be reached in assigning them to the same category?

Secondly, cases are found of morphemes which appear in both languages, have the same function and are subsumed under the same term, the hortative being a case in point. Hortatives describe a request or a wish, but are morpho-syntactically different in the two languages, possibly as a result of different

historical origins. In Zulu, the hortative is clearly an inflectional morpheme, appearing as a verbal prefix; in Northern Sotho however, it is a particle, which is a class independent free morpheme.

For instance, in the two ZUL examples in (4) a polite request and a stronger request or command are expressed by prefixing a hortative morpheme such as *ma* to the subjunctive form of the verb; or by inserting *bo* after the subject concord in the indicative form of the verb:

- (4) a. *Masibuye*
 ‘Let us return’
 b. *Ubohamba kusasa*
 ‘You must go tomorrow’

In Northern Sotho, the hortative appears in constructions similar to the first example, cf. (5 a). On the other hand, the hortative in Northern Sotho can also appear outside of the verbal structure; in fact, separated from the verb by the subject NP, cf. (5 b).

- (5) a. *A re boe*
 ‘Let us return’
 b. *A baithuti ba tsene*
 ‘Let the students enter’

In examples such as (5), the hortative *a* can clearly not be categorized as an inflectional verbal prefix, and based inter alia on the fact that it can be separated from the verb by means of another linguistic word, it is categorized as a particle – a category which is admittedly a rather idiosyncratic one. Rather than assigning hortatives to two different categories we decided to categorize all Northern Sotho hortatives to the category ‘hortative particle’ since this category would also provide for examples such as those in (5).

Thirdly, there are cases with inherent differences between the two languages. In Zulu, two types of quantitative pronouns are distinguished, i.e. inclusive and exclusive quantitative pronouns. The inclusive quantitative pronoun is characterised by a suffixal morpheme *-nke* which carries the meaning ‘the whole of’ in the singular form and ‘all’ in the plural form, cf. (6).

- (6) a. *bonke abantu*
 ‘all the people’
 b. *wonke umzimba*
 ‘the whole body’

The exclusive quantifier in Zulu is used to express ‘only’ or ‘alone’ and is marked by means of a suffixal morpheme *-dwa*, as in (7).

- (7) a. *amadoda odwa*
 ‘only the men’
 b. *umfana uhambe yedwa*
 ‘the boy went alone’

In Northern Sotho, only the inclusive category exists. The category exclusive quantitative pronoun would then be a language specific one which needs to be distinguished to make provision for Zulu, and for that matter for all the languages belonging to the Nguni group.

Moving further afield, although some noun classes (no longer) exist in either Northern Sotho or Zulu, the ontology needs to be flexible enough to provide for other languages in which these classes do appear. Approximately 27 distinct noun classes have been identified in the various languages

belonging to the Bantu language family (cf. Poulos and Msimang, 1998:28). Although there is no Bantu language that boasts the whole spectrum of these classes, they need to be provided for in an ontology of Bantu. For instance, classes 20 and 21 do not occur in Zulu and Northern Sotho, but they do occur in one of the other South African Bantu languages, namely Venda. Another example is the singular class 11 which is quite common in Zulu, but in the case of Northern Sotho, nouns which originally belonged to class 11, have been reassigned to class 5 (class prefix *le-*). In Tswana, a language closely related to Northern Sotho, class 11 is still distinguished with class prefix *lo-*, cf. (8).

- (8) a. *loleme* (Tswana) vs. *leleme* (Northern Sotho)
 PrefClass_11 + ROOT_NC PrefClass_05 + ROOT_NC
 ‘tongue’
- b. *losea* (Tswana) vs. *leseae* (Northern Sotho)
 PrefClass_11 + ROOT_NC PrefClass_05 + ROOT_NC
 ‘baby’

Another inherent language difference is the so-called relative construction which is language specific in our ontology, since it occurs in Zulu but not in Northern Sotho. The relative construction in Zulu is characterised by a relative morpheme which carries the meaning of ‘who/which/that’. Therefore the semantic function of the relative construction is that of qualifying the noun to which it refers, cf. (9).

- (9) a. *amanzi abandayo*
 ‘water **that** is cold’
- b. *umfundi ohlakaniphile*
 ‘a scholar **who** is intelligent’

It is significant that relative constructions may be formed from a variety of word categories, e.g. the copula construction, the verb, adverbial forms, possessive constructions as well as pronouns.

2.3 Language internal differences in grammatical descriptions

In 2.1 it was pointed out that differences in the descriptive frameworks can in some cases account for perceived differences between languages. Differences in grammatical descriptions within the same language can also be the result of different theoretical stances taken by linguists. We will only refer to two examples of such differences in descriptions, the first being the categorisation of radical pronouns vs enumeratives in Northern Sotho. Lombard (1985), following a structuralist approach categorizes the items *tee* ‘one’, *-šele* ‘strange’, *-fe* ‘which’ and *šoro* ‘cruel’ as radical pronouns, the term ‘radical’ in this case referring to its etymology, i.e. radix, meaning root. However, in the more functional approach taken by Poulos and Louwrens (1994) enumeratives are, together with adjectives and nominal relatives regarded as qualificatives, since their primary function is to qualify or describe a nominal antecedent. Their pronominal function is a secondary one, which is only fulfilled when the nominal antecedents of these enumeratives are deleted. In keeping with the functional approach, in our ontology we categorize enumeratives as qualificative roots.

A second example is the numbering system of the noun classes in Bantu. For ease of reference it has become customary in the description of the Bantu languages to assign numbers to the different noun class prefixes. In our ontology, we follow Meinhof’s (1932:48ff) numbering system of the noun class prefixes. In general, the uneven class prefixes represent singular prefixes with the following even number representing the corresponding plural prefix. There are, however, some exceptions such as the prefixes of class 15, as well as those of the locative classes that are not associated with any

grammatical number. It should be noted that there are other approaches to noun class categorisation as well, for example Doke's numbering system that divides classes into singular and plural pairs with a single number for each pair.

2.4 Morphosyntactic phenomena not described previously

Although both Northern Sotho and Zulu are to a large extent standardized in the sense that their grammars have been extensively described and investigated, some linguistic phenomena seem to have slipped through the cracks of grammatical description. In Northern Sotho for example, a whole paradigm of concordially based forms are not mentioned in any grammar, nor have they been the object of any form of linguistic investigation, despite their high frequency of use. They consist of a prefixal element *na-* which is affixed to a shortened form of the so-called emphatic pronoun and carries the meaning '(together) with him/her/it/them', e.g. *nabo* 'with them' (class 2), *naye* 'with him/her/it' (class 1) and *natsō* 'with them' (class 8/10). These forms do not readily fit into any of the existing word classes of Northern Sotho, although it could be argued that function-wise, they could be categorized as adverbs. Adverbs however, normally do not contain a concordial element. In cases such as these, a decision needs to be taken by the expert linguists as to the correct categorization of these forms – in this case, it was decided to add the whole paradigm to the category adverb, based on the function of these forms.

3 Design of the data model, the contents and front end

When designing a database (DB), especially a relational one like a MySQL-DB, one should distinguish between data items and relations between those items. Languages, morphological categories like part of speech, number or noun class are viewed as data items, as are the morphemes themselves. Each of those data items is stored only once in the database. By assigning one morpheme to a language and to a part of speech (and possibly, to a noun class and a number), we create a relation which is then stored in a relational table (see "morph_assign" in Figure 3). The lines connecting the tables in Figure 3 describe the numeral relation between entries in the tables: 1:n means that each morpheme appearing once for instance in the table "morphemes" may appear several times in the table "morph_assign". Diamonds stand for primary (unique) keys, filled circles mean that for each entry, this field has to be filled, empty circles mean that filling the field is optional.

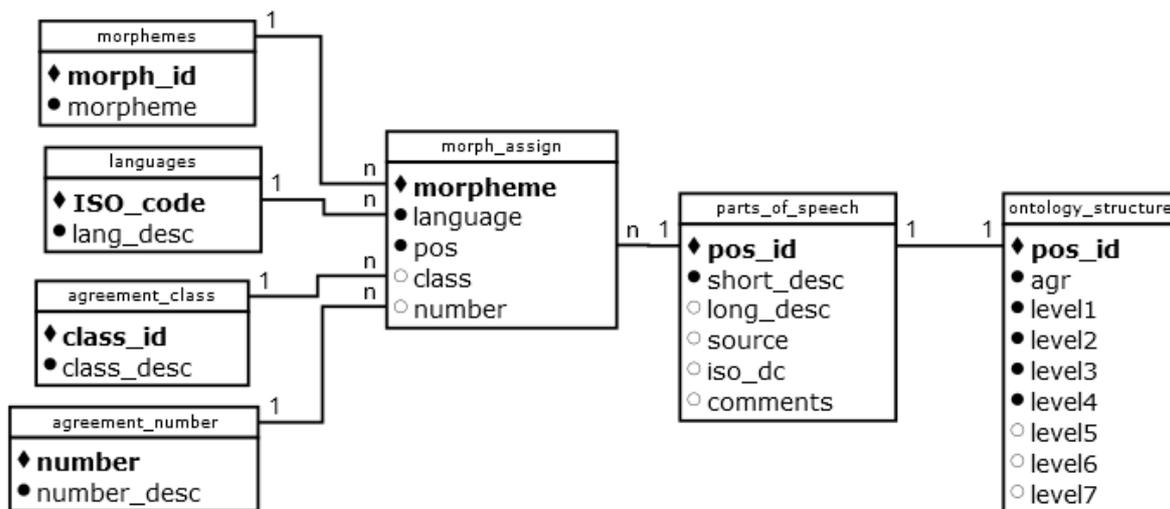


Figure 3: Database design

In our database, one table, namely the table “morphemes” is to contain all of the morphemes and allomorphs³; the field “morpheme” is defined as unique which means that each morpheme may only appear once in the table. The table “languages” is generated to contain all languages to be described. There is also a table “parts-of-speech” describing categories with additional information like short and long description and a respective ISOCAT⁴ data category, if available (cf. Pretorius and Bosch, 2014). The table “ontology-structure” represents the levels described above for each of the morpheme categories and is connected 1:1 with the table “parts_of_speech” to make sure that no morpheme category will be added to the database that is not sorted into the hierarchy first. Lastly, there are tables containing all known data items of “class” (including 1st and 2nd person), and “number”. The relational table *morph_assign* lastly contains all of the assignments of all morphemes each to a part-of-speech category, a language and, if appropriate, a class and number information.

3.1 Populating the database

There are several ways to populate the database; we opted for adding most of the data from excel-sheets that had been filled in by language experts. These experts also had the option of using the editing function of the database (see section 3.4) to correct, delete or add items. For adding further languages, such as Tswana, it is possible to generate an excerpt of the database containing all of the Northern Sotho assignments in excel sheets. A language expert can then change the data with an external program before these are added collectively to the database by the database administrator. New single assignments can be done by language experts with editing rights via the interface which is described below.

Concerning the front end, we distinguish three kinds of users (see also section 3.3): (1) the browsing user may only examine the data contained, but may not make any changes ; (2) the maintainer can

³ We distinguish allomorphs (like *tlo* and *tla* both being future tense morphemes of Northern Sotho; and *umu* and *um* both being class 1 noun prefixes of Zulu) and the results of morpho-phonological changes at word boundaries when merging morphemes. Results of the latter are not contained in the database.

⁴ <http://www.isocat.org/rest/dcs/119#index>

add, delete or edit single morphemes and/or morpheme assignments, and (3) the database administrator, who has all the rights above and may do all else, such as adding external data from lists (or excel sheets) provided by language experts or deleting data that exhibit certain properties, e.g. morphemes that are not assigned to any category.

3.2 Contents of the current database

So far, 60 different morpheme categories are fully described and sorted into the hierarchy. A total of 1.045 assignments (590 for Zulu and 455 for Northern Sotho) for 588 different morphemes have been stored. In Northern Sotho, *go* shows the highest number of assignments, namely 13, followed by *a* and *ba*, each with 12. In Zulu, *ku* and *ba* each are assigned to 11 morpheme categories, followed by *zi* with 9 assignments. We find altogether 34 morphemes which are assigned to both languages, most of them to several categories, see Table 1 for an excerpt. Figure 4 demonstrates the current assignments for the morpheme *wa*.

<i>Morpheme</i>	<i>Assignments to ZUL</i>	<i>Assignments to NSO</i>	<i>Total no. of assignments</i>
<i>a</i>	9	12	21
<i>ba</i>	11	12	23
<i>be</i>	3	2	5
<i>bona</i>	2	2	4
<i>ma</i>	4	1	5
<i>lona</i>	2	2	4
<i>wa</i>	8	4	12
<i>wena</i>	1	1	2
<i>wona</i>	4	2	6
<i>yena</i>	2	1	3
<i>yona</i>	2	4	6

Table 1: An excerpt of morphemes assigned to both Zulu and Northern Sotho

morpheme	language	pos	class	number
wa	NSO	CPoss	01	
wa	NSO	CPoss	03	
wa	NSO	CS	03	
wa	NSO	CS	2p	sg
wa	ZUL	CO	06	p1
wa	ZUL	CPoss	01	
wa	ZUL	CPoss	03	
wa	ZUL	CPoss	1p	sg
wa	ZUL	CPoss	2p	sg
wa	ZUL	CS	01	
wa	ZUL	CS	03	
wa	ZUL	CS	2p	sg

Figure 4: Current assignments for the morpheme *wa*

All morpheme categories contained in the database have been provided with a description in the form of a terminological definition. The aim of these definitions is to enable linguists who would want to

enter the data of any other language to identify the proper category where their data should be entered. This is necessary since as we have pointed out in section 2.2 above, differences in the linguistic descriptions of languages may obscure similarities between languages. Although not all definitions have been done within the classical genus-differentiae convention of terminological definitions, we have attempted to refer to the relevant superordinate concepts of the term being defined whenever possible and / or applicable. By doing so, we have tried to give some indication of the conceptual relationship between the concept being defined and other related concepts. In this way, we give some indication of the position of the morpheme in the diagram. The definition of the applicative verbal extension (SuffExtAppl) and its position in the relevant diagram are given as an example in Figure 5.

Description:

The applicative verbal suffix, indicates that an action is carried out for, on behalf of, to the detriment of, or in the direction of someone or something. Affixation may result in phonological changes to the final syllable of the verb stem. Can increase the degree of transitivity of the verb. It is also known as the applied suffix.

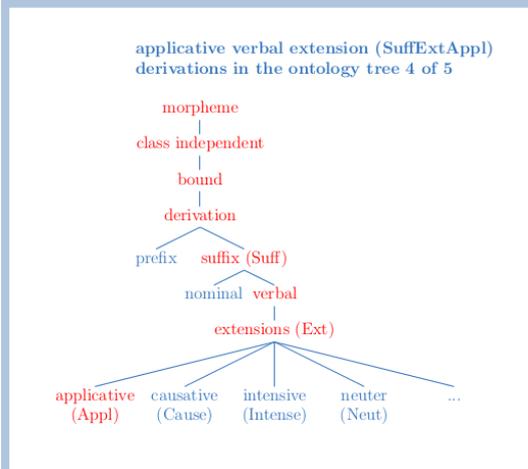


Figure 5: Long description and ontology tree for SuffExtAppl

Our long descriptions are furthermore an attempt to provide for both language specific and general linguistic information. In cases where we are aware of different interpretations of specific linguistic phenomena, a reference to such viewpoints is already made in the description. Compare in this regard our definition of the potential morpheme, which we regard as an aspectual morpheme, but which is described as a marker of a potential mood in some grammars:

“The potential morpheme expresses aspectual notions such as possibility, permission and condition. In some grammatical descriptions, the potential is regarded as a separate mood or verb form.”

3.3 Browsing and editing data (front end)

The current front end of our database is still a beta version; however, we assume it to be fully functional. Figure 6 shows the starting screen⁵. The user may click on the elements that (s)he is interested in. It is possible to double click on a morpheme to obtain information about the assignments for this morpheme (the result of such an action for the morpheme *wa* is displayed in Figure 4) or to generate a selection by clicking on a language, a morpheme category, and/or on class and/or a number,

⁵ <https://www.uni-hildesheim.de/iwist-cl/projects/ontology/>

followed by clicking on the “select” button. As Figure 7 exemplifies, only the morphemes of the selected categories are then displayed.

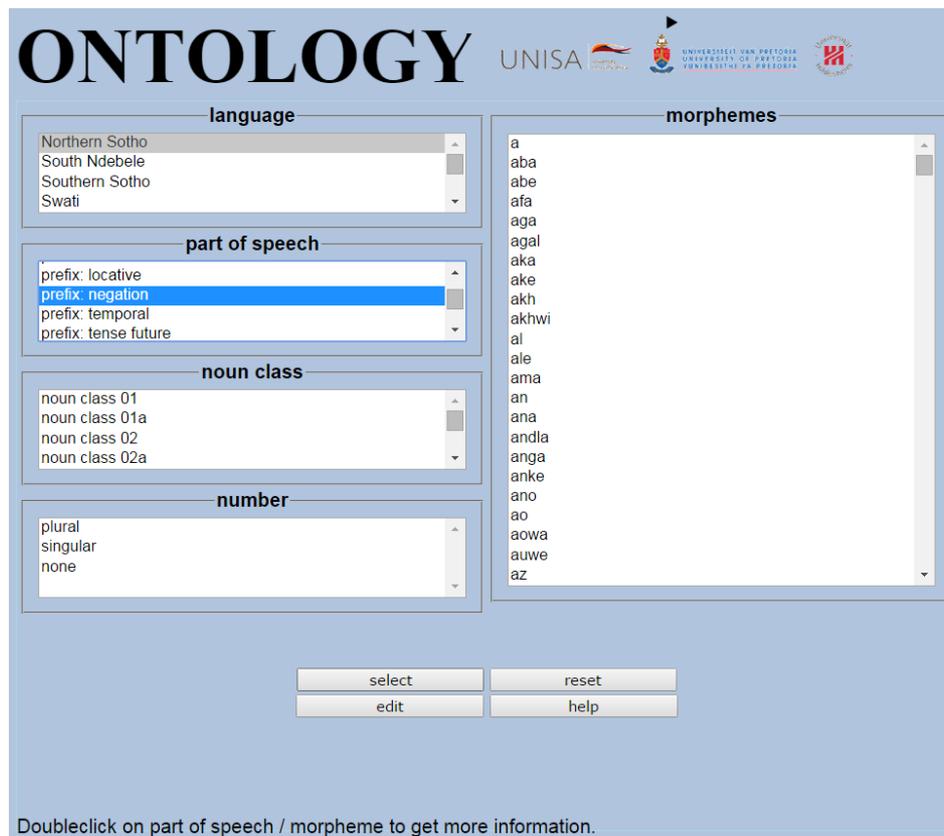


Figure 6: Selecting “Northern Sotho” and “prefix: negation” on the start screen

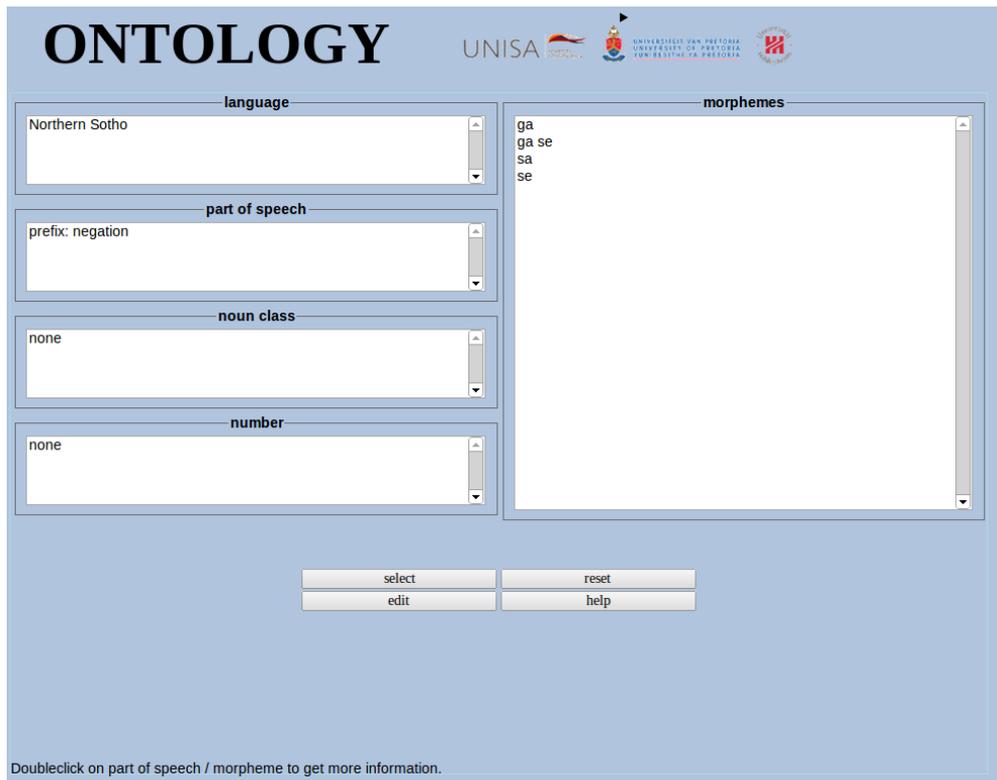


Figure 7: Resulting screen after clicking on “select”

If a user needs more information about a part of speech category, (s)he may double click on the respective part of speech. This action will lead to a pop-up window giving the long description of the data item and the path to it through the ontology, as shown in Figure 5 above.

After login (clicking on the “edit” button leads to a login screen), a language expert may add or change morpheme assignments to the parts of speech described in the database. In case a new morpheme is assigned, it is added to the database automatically; if the last assignment for a morpheme is deleted, the morpheme itself is deleted in the database too. Language experts may not change the existing hierarchy. This is to ensure that all categories are discussed with all language experts involved before they are changed, added or deleted. Such activity may only be performed by the administrator who makes sure that all experts agree. Figure 8 shows the edit mode which appears after login.

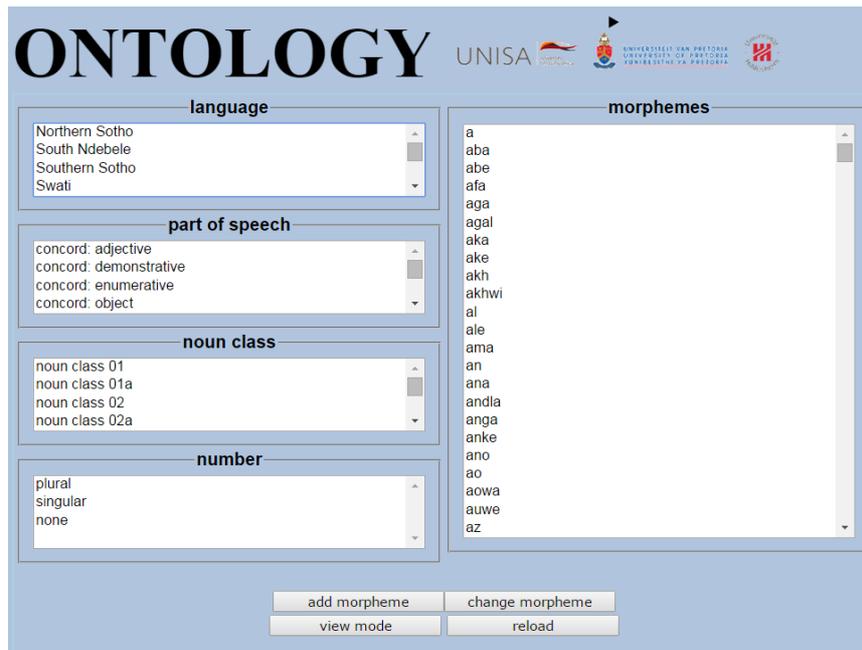


Figure 8: Ontology edit mode

In case the expert finds that an assignment is missing in the ontology, (s)he may click on the button “add morpheme” to trigger a new window that allows the necessary selections, see Figure 9.

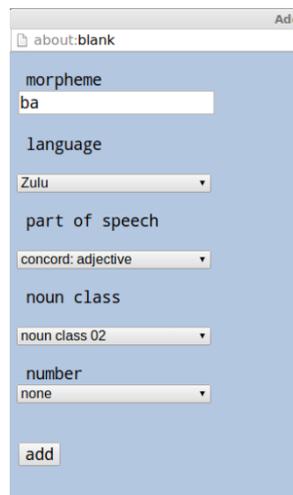


Figure 9: Assigning/adding a morpheme
(*ba* as an adjective concord of class 2 in Zulu)

Assuming that an assignment for a morpheme is to be changed, the expert may select the morpheme (in our example, it is *se*) and click on “change morpheme”. An edit window appears in which the expert can either edit or delete assignments, see Figure 10.

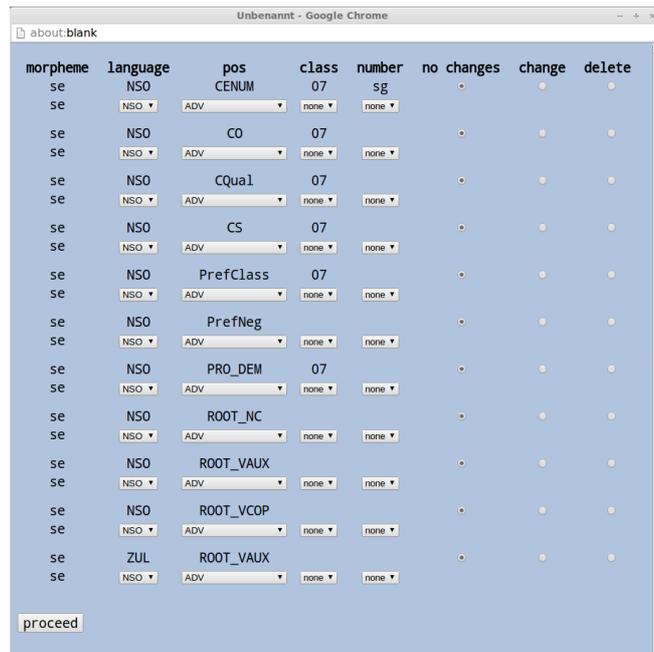


Figure 10: Editing assignments of the morpheme *se*

3.4 Extension to other languages (roadmap)

The preceding detailed account of the methodology for the population of the database, serves as roadmap for linguists specializing in other Bantu languages for extension of the database. It was shown that the database is extendable via the web so that data from Bantu languages in various degrees of relatedness can be added.

A case in point is the relative suffix. In Zulu as well as in Northern Sotho, the relative suffix is an invariable, class independent morpheme as shown in (10) and (11).

Zulu

- (10) a. ...*umfana ofundayo*
 ‘...the boy who studies’
 b. ...*abafaba abafundayo*
 ‘...the boys who study’

Northern Sotho

- (11) a. ... *mošemane yo a kitimago*
 ‘the boy who is running’
 b. ... *bašemane ba ba kitimago*
 ‘the boys who are running’

However, in some Bantu languages, e.g. Swahili, the relative suffix morpheme is actually class dependent, which implies that additional provision would have to be made for such a morpheme within the ontology as shown in (12). This further motivates our decision to implement a flexible ontology.

Swahili

- (12) a. ... *mntu asomaye*
 ‘a man who reads’

- b. ... *kengele iliayo*
 ‘a bell which rings’

In these examples it is illustrated that that co-variance or agreement exists between the relative suffix morpheme appearing in bold and the antecedent. Although in Swahili this bold-printed form is regarded as an absolute pronoun, it occurs in the same position and has the same function as the described relative suffix morpheme in the other languages that have been exemplified, the difference being that it agrees in class with the antecedent.

In Tsonga, the vowel of the relative suffix has become phonologically identical to the final vowel of the verb stem (cf. Poulos, 1986:287-288), and is therefore no longer an invariable morpheme, see (13).

Tsonga

- (13) a. *vanhu lava va vulavulaka ...*
 ‘people who are talking...’
- b. *vanhu lava va nga vulavuliki*
 ‘people who are not talking...’

For cases described in (11) to (13), new categories will therefore have to be added to the ontology. The language expert should hence contact the database administrator suggesting the category and its position in the ontology. The administrator will then contact the language experts involved to find a consensual solution.

4 Conclusion and future work

The ontology of morphological items can be used as a separate knowledge base for the use of linguists. However, we plan to also connect it with the lexicographic database currently developed in the SeLA project (Faaß et al., 2014). This is because we assume users not familiar with the Bantu languages to enter fully fledged orthographic words when seeking lexicographic information. A morphological analyser is planned which will split the given orthographic word (if necessary) into lexicographic units (e.g. stems) for which lexicographic information can subsequently be found in the SeLA database. If a user enters a grammatical morpheme which is not contained in the SeLA database, the ontology database will be able to provide a description. The morphological analyser will hence make use of the ontology database so that information on morphological units not provided with lexical information can also be shown to the interested user.

As described above, we are now aiming at an extension of the ontology database towards other Bantu languages and interested language experts are invited to contact us for future collaboration.

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