

The Hunting of the BLARK – SALDO, a Freely Available Lexical Database for Swedish Language Technology

Lars Borin, Markus Forsberg

Lennart Lönngren

University of Gothenburg
Department of Swedish

University of Tromsø
Department of Russian

*For the Snark's a peculiar creature, that won't
Be caught in a commonplace way.
Do all that you know, and try all that you don't:
Not a chance must be wasted to-day!*
(Lewis Carroll: *The Hunting of the Snark*)

1 Introduction

Among Anna Sångvall Hein's numerous professional interests, computational morphology and the lexicon were among the very earliest. Her implementation of a full computational inflectional morphological processor for Russian was the topic of her PhD thesis (Sångvall, 1973). In the 1980s, she headed the LPS project¹ at the University of Gothenburg. A summary description of her work in the LPS project, on a computational lexicon for parsing is found in Sångvall Hein 1988.

Among her most recent research interests, on the other hand, is the creation of a research infrastructure for Swedish language technology, more specifically a Swedish BLARK² (see below).

Against this background, what would be more appropriate than to dedicate this article about a lexicon component of a Swedish BLARK to Anna?

The need for a basic research infrastructure for Swedish language technology is increasingly recognized by the language technology research community and research funding agencies alike. At the core of such an infrastructure is the so-called BLARK – Basic LAnguage Resource Kit. A planning project funded by the Swedish Research Council has been set the tasks of defining

¹A Lexicon-oriented Parser for Swedish.

²See, e.g., Anna Sångvall Hein and Eva Forsbom: *A Swedish BLARK*, presentation at BLARK workshop, 29th January 2006, GSLT retreat, Gullmarsstrand, Sweden (<http://stp.lingfil.uu.se/~bea/blark/sveblark060129.pdf>).

Swedish BLARK components, surveying the availability and state of the art of these components, and determining the needs for the immediate future. One BLARK component identified during this work as lacking at present is a freely available basic Swedish lexicon with (inflectional) morphological information, containing at least 50,000 lemmas (Andréasson et al., 2007).

Here we describe our work on creating such a lexical resource, which will also contain additional useful linguistic information. This resource is SALDO, or SAL version 2 (see section 2). SALDO currently comprises a semantic lexicon (described in section 3), a morphological lexicon (discussed in section 4), and a computational morphological description written in FM (Forsberg, 2007), including a full-form lexicon generated with FM (treated in section 5). All components will be released under a Creative Commons Attribute-Share Alike license.³

2 SALDO: Background and Scope

Svenskt associationslexikon (SAL; Lönngren, 1992) – ‘The Swedish Associative Thesaurus’ – which formed the basis for SALDO, is a so far relatively little known Swedish thesaurus with an unusual semantic organization.

SAL was created during the years 1987–1992 by Lennart Lönngren and his co-workers in the Center for Computational Linguistics at Uppsala University.⁴ SAL has been published in paper form in two reports, from the Center for Computational Linguistics (Lönngren, 1998), and the Department of Linguistics (Lönngren, 1992), both at Uppsala University. Additionally, the headwords and their basic semantic characterizations have been available electronically, in the form of text files, from the very beginning.

The history of SAL has been documented by Lönngren (1989) and Borin (2005). Initially, text corpora were used as sources of the vocabulary which went into SAL, e.g., a Swedish textbook for foreigners and a corpus of popular-scientific articles. A small encyclopedia and some other sources provided the large number (over 3000) of proper nouns found in SAL. Eventually, a list of the headwords from *Svensk ordbok* (SO, 1986) was acquired from the NLP and Lexicology Unit at the University of Gothenburg, and the second paper edition of SAL (Lönngren, 1992) contained 71,750 entries. At the time of writing, SALDO contains 72,557 entries, the increased number being due to some new

³<http://creativecommons.org/licenses/by-sa/3.0/>

⁴Gunilla Fredriksson worked together with Lennart Lönngren on the lexeme definitions and Ágnes Kilár did most of the programming in the original project. Incidentally, the Center for Computational Linguistics was a research unit created in 1980 on the initiative of Anna Sägval Hein who was its director until she accepted the chair in Computational Linguistics at Uppsala University in 1990 and the Center was merged with the Linguistics Department. Lennart Lönngren – a Slavist by training, like Anna – acted as her replacement for some years while Anna was acting professor of Natural Language Processing at the University of Gothenburg, which was when she did a great part of her work on the LPS lexicon.

words having been added, but mainly because a number of entries belong to more than one part of speech or more than one inflectional pattern.

The work described here first started in late 2003, when Lars Borin and Lennart Lönnngren initiated a collaboration aiming at making SAL available for online browsing through Språkbanken (the Swedish Language Bank at the University of Gothenburg). Part of this work consisted in a formal check of the lexicon, which revealed some circular definitions, that were subsequently removed. In 2005, a computational linguistics student made a prototype graphical interface to SAL (SLV – Språkbanken Lexicon Visualization; Cabrera, 2005). Using this interface, Lennart Lönnngren was able to revise a considerable number of entries with respect to their semantic characterization, so that SALDO is in this respect no doubt a new edition of SAL, i.e., also as a semantic lexicon.

We soon realized, however, that in order to be really useful in language technology applications, SAL would have to be provided at least with inflectional morphological information. Thus the work on SALDO began.

3 SALDO: A Semantic Lexicon

As a semantic lexicon, SALDO is a kind of lexical-semantic network, superficially similar to WordNet (Fellbaum, 1998), but quite different from it in the principles by which it is structured.

The organizational principles of SALDO are quite simple – at least superficially – as there are only two primitive semantic relations, one of which is obligatory and the other optional. Every entry in SALDO must have a *mother* (or *main descriptor*), a semantically closely related entry which is more central, i.e., semantically less complex, probably more frequent and acquired earlier in first and second language acquisition, etc. The mother will in practice often be either a hyperonym (superordinate concept) or synonym of the headword (but it need not be either). In order to make SALDO into a single hierarchy, an artificial most central entry, called PRIM, is used as the mother of 50 semantically unrelated entries at the top of the hierarchy, making all of SALDO into a single rooted tree.

Some entries have in addition to the mother an optional *father* (or *determinative descriptor*), which is sometimes used to differentiate lexemes having the same mother.

SALDO (or rather: the underlying SAL) is unusual in several respects:

- it contains a number of proper nouns and multi-word units, not normally found in conventional print or electronic dictionaries;
- it is strictly semantic in its organization; all entries are *lexemes* – i.e., semantic units – and there is no information whatsoever about part of speech or inflection; homonymous entries representing more than one

part of speech are often treated as different, but always because of their semantics and never for inflectional reasons;⁵

- the organizational principles of SALDO are different from those of lexical-semantic networks such as WordNet, in that the semantic relations are more loosely characterized in SALDO. They also differ from those of more conventional thesauruses, however, but in this case by having more, as well as more structured, sense relations among lexemes.

Below, we give a few examples of entries with their mother and father lexemes, randomly selected under the letter “B” of Lönngren (1992):

balkong : hus (‘balcony’ : ‘house’)
bröd : mat + mjöl (‘bread’ : ‘food’ + ‘flour’)
brödföda : uppehälle (‘daily bread’ : ‘subsistence’)
bröllop : gifta sig (‘wedding’ : ‘get married’)
Bulgakov : författare + rysk (‘Bulgakov’ : ‘author’ + ‘Russian’)

How SALDO is different from typical thesauruses becomes apparent when we consider that the two primitive lexical-semantic relations (*mother* and *father*) can form the basis of any number of derived relations. Thus the relation ‘sibling having the same mother (as myself)’ is very interesting, as such sibling groups tend to correspond to natural semantic groupings.

4 SALDO: A Morphological Lexicon

SAL did not contain any formal information about entries, not even an indication of part of speech. Thus, one important difference between SALDO and SAL is that SALDO now has full information about the part of speech and inflectional pattern of each entry.

The morphological description in SALDO was inspired by that of Sågval Hein’s LPS lexicon, even if the two descriptions differ in many details. The main differences are due to slightly different conceptions of what can constitute an inflectional pattern. In our view the inflectional pattern should be characterized as a set of bundles of morphosyntactic features conventionally expressed inflectionally in a language. We do not make a distinction between affixing and other means of morphological exponence. For instance, Swedish nouns conventionally (maximally) express the following bundles – or combinations – of morphosyntactic features:

singular indefinite nominative
singular definite nominative
singular indefinite genitive

⁵For example, the entry *alternativ* ‘alternative’ is considered to represent only one lexeme, although in Swedish as in English it has both a noun and an adjective reading.

singular definite genitive
plural indefinite nominative
plural definite nominative
plural indefinite genitive
plural definite genitive

There may be subclasses or individual cases of the main parts of speech which express fewer – or, in rare individual cases, more – such combinations, e.g., nouns appearing only in the singular or only in the plural.

In a non-agglutinating language, words will fall into inflectional patterns according to how the combinations are expressed.⁶ Such patterns are conventionally known as declensions in nominal parts of speech and conjugations in verbs.

At the time of writing, with a few hundred multi-word units still to be assigned inflectional patterns and before the final checking of the lexicon, there are more than one thousand different inflectional patterns represented in the lexicon. This does not differ radically from what Sågvald Hein (1988) found when working on the LPS lexicon, although the large number of inflectional patterns in our description is there partly for different reasons than in her case.

For example, there are no artificial ‘half-paradigms’ in SALDO, due to e.g., umlaut plural or ablaut tense formation; these are considered full inflectional patterns in their own right, just as those expressing the same categories by suffixation.

Still, there are many singleton inflectional patterns. In many cases, these are the irregular words of traditional grammar, although there are also subregularities (e.g., among the strong verbs). Surprisingly often, however, the source of plenty is another, viz. variation. We often find that a particular combination of morphosyntactic features – a particular cell in a paradigm – for a word or small group of words can be filled by more than one form, i.e., realized in more than one way. Such cases are legion, e.g., *himmeln*, *himlen*, *himmelen* ‘heaven sg def nom’ (citation form *himmel*), which in all other respects follows the inflectional pattern designated in SALDO as *nn_2u_nyckel*, which includes words like *nyckel* ‘key’, *åker* ‘field’, *öken* ‘desert’, *hummer* ‘lobster’. This pattern allows only for the first of the three variants shown above for the singular nominative definite form of *himmel*, i.e., the form made by affixing an *-n* to the citation form.

There is an interesting theoretical issue lurking here. For Wurzel (1989, 57), an inflectional class (which he uses as a technical term) must have more than one or even just a few members, although he is not prepared to commit himself to a specific lower limit. A practically useful computational lexicon should in any case specify the morphological behavior of individual words as accurately

⁶Agglutination is – ideally – the case where each morphosyntactic feature is expressed separately and uniformly, so that there will in principle be no inflectional patterns beyond those determined by part of speech.

as possible. In SALDO, this behavior is encoded uniformly for all words – in the form of a unique identifier for each inflectional pattern⁷ – i.e., in the lexicon we do not make a distinction between inflectional classes and individual cases in Wurzel’s sense. This task is relegated to the computational morphological component, where a mapping is made between SALDO’s inflectional patterns and regular, subregular and idiosyncratic inflectional descriptions. However, it is not difficult to get a picture of which inflectional patterns are general and which idiosyncratic. It suffices to extract and count all inflectional pattern designators from SALDO. The following is a list of the inflectional patterns with more than 1000 members in (the still not final version of) SALDO:

| | | | | | |
|------|------------|------|---------------|------|--------------|
| 9507 | nn_3u_film | 4278 | nn_0u_frid | 1216 | nn_0n_kaos |
| 7787 | nn_2u_stol | 3945 | nn_1u_flicka | 1084 | ab_i_inte |
| 5901 | av_1_gul | 1826 | nn_6u_kikare | 1046 | av_0_korkad |
| 5700 | nn_6n_blad | 1319 | nn_0u_tro | 1018 | nn_2u_nyckel |
| 5528 | vb_1a_laga | 1305 | nn_5n_ansikte | | |

These 14 inflectional patterns account for over 50,000 entries or more than 70% of SALDO.

Something which adds to the number of inflectional patterns is that we also encode some inherent features of words in the inflectional pattern designators, features which do not bear directly on the inflectional behavior of the word itself. However, they are potentially useful and comparatively easy to add simultaneously with the morphological information proper, but can be quite difficult to add later, e.g., the gender of nouns, agreement and anaphorical gender in proper names, etc.

In adding the morphological information to SALDO, we have used existing grammatical descriptions of Swedish inflectional morphology – above all *Svenska Akademiens grammatik* (Teleman et al., 1999), but also Hellberg (1978) – as well as the inflectional information provided in existing Swedish dictionaries, primarily *Nationalencyklopedins ordbok* (NEO, 1995; in the form of the lexical database which was used for producing NEO), but also its predecessor *Svensk ordbok* (SO, 1986), and *Svenska Akademiens ordlista* (SAOL, 2006).

For practical and sometimes theoretical reasons we have deviated from these descriptions (which – we should add at this point – are not always consis-

⁷The identifiers were designed to have some internal structure for the benefit of humans working with the lexicon. We cannot for reasons of space go into any details here – they will be given in full in the documentation to accompany SALDO – but just to give the reader a flavor of how identifiers are built up: The identifier `nn_3u_film` below conveys the information that this is a third declension (“3”) utter gender (“u”) common noun (“nn”) inflected like the noun *film* ‘film’.

tent among themselves). For example, we have not found Hellberg's "technical stem" a useful concept.⁸

The inflectional information in SALDO deviates from that found in conventional dictionaries at least on two counts:

1. Our inflectional patterns are quite generous as to which forms are supposed to exist for a lemma. We thus subscribe to the notion of "potential form" which is inherent in the concept of inflectional paradigm, the general principle being that there should be a clear(ly statable) grammatical, semantic or pragmatic reason for us to postulate the absence of some form or forms in the paradigm of a lexical item. In practice, this is often the case with number in nouns, comparison in adjectives and certain adverbs, and past (passive) participles in verbs. This principle means that SALDO recognizes fewer uninflected items than traditional dictionaries (e.g., *dna/DNA*, which in SALDO also has indeterminate gender, to boot; both *dna:t* and *dna:n* are valid definite forms, according to SALDO). In general, then, if SALDO differs from modern Swedish reference dictionaries, SALDO will accept more forms for a lemma. The only systematic exception to this is that we recognize a class of verbs that do not form past participles, an inflectional pattern that the dictionaries do not seem to recognize at all.⁹ Thus, in SALDO, we distinguish between two second-conjugation verb lemmas *väga* 'weigh', where traditional dictionaries recognize only one verb lemma with two meanings, only one of which correlates with the ability to form the past participle:

väga vb_2a_leva (i.e., *väger, vägde, vägt, vägd*)
väga vb_2m_väga (i.e., *väger, vägde, vägt, -*)

2. A lexicon for language technology must lend itself to the analysis of arbitrary free text, e.g., on the internet, where we will find many word forms which are not accepted by normative dictionaries of the written language, but still recognizable as possible variant inflected forms of some existing lemma. Hence, the SALDO morphology recognizes many attested (but not normative) forms, e.g., the lemma *datum* with utral gender and corresponding double indefinite plural forms in *-ar/-er*). We also recognize some variant spellings which are not in the norm, but not "prototypical" misspellings (although the borderline between the two is far from sharp). For example, *microvågsugn* is a quite common spelling for

⁸Hellberg himself says that the technical stem is something that he has had to resort to because of technical shortcomings (Hellberg, 1978, 15f), and which have since then been eliminated.

⁹We are still somewhat more conservative in this respect than Sägval Hein (1988, 285ff), who distinguishes four classes of (non-phrasal) verbs, according to their ability to form s-forms and the past participle.

mikrovågsugn (prescribed by the orthographic norm). How should we treat this spelling (67,000 Google hits as opposed to 182,000 for the ‘correct’ spelling, in early December 2007)? In the SALDO morphology it is considered a variant spelling.

SALDO is thus not a normative lexicon, but rather strives to be maximally descriptive. At the same time the notion of inflectional patterns (inflectional classes, paradigms) contains a kind of normativity, namely that which is an irreducible element of linguistics itself, i.e., the formulation of lawlike generalizations about our languages. It is also a recognition of the fact that, however large a corpus we collect, we will never see all the inflected forms of all the entries in our lexicon, not even in a morphologically challenged language like Swedish.¹⁰

At the same time we know as language users that some forms of some words are not only not attested, but actually non-attestable, e.g., the past participle forms of some verbs, or comparative and superlative forms of (participle-like) Swedish adjectives in *-ad* (e.g., *långfingrad*). The reasons for the lack of some forms in a paradigm can be various, semantic or formal (the latter seems to be the case for the adjectives in *-ad*), but paradigms can also have “holes” in them for completely idiosyncratic reasons (Hetzron, 1975). In the SALDO morphology, we take this into account to some extent, but we have preferred to err on the side of generosity in unclear cases, which means that our morphological description probably overgenerates. If the lexicon is used in language technology applications for analysis, this is not a problem, as long as a potential but impossible form does not coincide with an actual other form. The problem of dealing with this if the lexicon is to be used in natural language generation applications is left for future work.

5 FM for Swedish

Functional Morphology (FM; Forsberg, 2007) is a tool for implementations of computational morphological descriptions. It uses the typed functional programming language Haskell (Jones, 2003) as the description language and supports (compound) analysis, synthesis and compilation to a large number of other formats, including full form lists, XFST (Beesley and Karttunen, 2003) source code, and GF (Ranta, 2004) source code.

FM has been around for a couple of years now and has been successfully applied to a number of languages: Urdu (Humayoun, 2006), Arabic (Smrz, 2007), old and modern Swedish, Italian, Spanish (Andersson and Söderberg, 2003), Russian (Bogavac, 2004), Estonian, and Latin.

The starting point of SALDO’s morphological description is the FM implementation of modern Swedish developed by Markus Forsberg and Arne

¹⁰On the other hand, this is no more to be expected than you would expect at some point to have seen “all the sentences of the language” as you collect more and more text.

Ranta, which consists of an inflection engine covering the closed word classes and the most frequent paradigms in the open word classes. All in all, the existing implementation covered approximately 80% of the headwords of SALDO, but only less than a tenth of the inflectional patterns, or paradigms.

The remaining paradigms in SALDO, however, are typically variants of already existing paradigms rather than being fundamentally different.

For example, consider the paradigm of *vers*, which is ambivalent in being a second or a third declension noun. It may be implemented as a combination of the inflection functions of second (`nn2`) and third (`nn3`) declension, exemplified in the function `nnvvers`.

```
nnvvers :: String -> Noun
nnvvers vers = combine (nn2 vers) (nn3 vers)
```

Another example is paradigms with one or more additional word forms, such as the paradigm of *kyrka*, a first declension noun with the additional compound form *kyrko*, as defined in the function `nnlkyrka`.

```
nnlkyrka :: String -> Noun
nnlkyrka kyrka =
  compvariants [tk 1 kyrka ++ "o"] (nn1 kyrka)
```

A complete implementation of a paradigm requires two more things, the interface function of the paradigm and the connection of the interface function to a paradigm identifier (see Forsberg 2007 for details).

The required time to implement a paradigm may vary, but a mean time is around 15 minutes per paradigm. This is a reasonable effort to spend on productive paradigms, but for the paradigms containing just one member it becomes prohibitively large. One possibility would be to resort to a simple enumeration of the worst-case word forms, i.e., the non-derivable word forms. However, we still need these paradigms to be productive, not only for aesthetic reasons, but to be able to treat compounds where these irregular words appear as the head.

We chose to create worst-case paradigms where word forms are described as pairs of suffixes and stem operations. A stem operation is a function from a string to a string, which allows arbitrary computation to be done to the headword before concatenated with the suffix, i.e., we have the same expressiveness as before.

This is best explained with an example, here with the paradigm of *man*, which is one of the more complicated noun paradigms with gemination and umlaut. The stem operation `id` leaves the stem intact, `ge` is a gemination function, and `um` performs umlaut on the stem vowel. We only give the four nominative word forms (variation enclosed in squared brackets), since the genitive is derivable.

```
paradigm "nn_6u_man" ["man"] $
noun_f Utr
```

```

([ (id, ""), ], -- man
 [ (ge, "en"), ], -- mannen
 [ (um, ""), (id, ""), (ge, "ar") ], -- män, man, mannar
 [ (ge.um, "en"), (ge, "arna") ]) -- männen, mannarna

```

The reason why it is considerably faster to implement paradigms with worst-case functions is partly because the whole definition is at a single place, but also because an implementation of a paradigm is decoupled from the rest of the implementation, which makes it more of a mechanical task. The drawback is that the paradigm implementations become less declarative.

The FM implementation of the SALDO morphology is now very close to complete, and the next step will be to ensure the correctness of the implementation.

All paradigms have example headwords in their definition, and FM can compute the inflection tables of these words. The first step will be to proofread these tables. The next step will be to run spellcheckers on the full form word list, which will not only allow us to spot errors in the inflection engine but also in the annotation.

6 Conclusion

So far, there has not been a freely available full-sized computational lexicon for Swedish providing inflectional morphological information for all entries. There are certainly several Swedish computational lexicons in existence, including lexicons with inflectional information, some of them quite large – including Anna Sångvall Hein’s LPS lexicon – but none freely available, which SALDO will be. In addition, it will put a new kind of thesaurus at the hands of researchers in Swedish Language Technology, a field pioneered by Anna.

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