Multilingual Processing of Auxiliaries within LFG

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Abstract

This paper proposes an analysis of English, French, and German auxiliaries in the context of parallel grammar development. We present an LFG implementation of the analysis which factors out language particular morphological wellformedness conditions from linguistically generalizable contributions of auxiliaries. Auxiliaries are treated as feature carrying elements, rather than as raising verbs. This avoids unnessary structural complexity and provides a uniform crosslinguistic analysis which eases the burden for machine translation.

Im Kontext der parallelen Grammatikentwicklung wird eine Behandlung von Auxiliaren im Englischen, Französischen und Deutschen vorgeschlagen. Die LFG Implementierung trennt sprachspezifische morphologische Wohlgeformtheitsbedingungen klar von linguistisch generalisierbaren Beiträgen der Auxiliare, indem Auxiliare nicht als *raising* Verben, sondern als funktionale Elemente behandelt werden. Somit wird unnötige strukturelle Komplexität vermieden, und eine einheitliche sprachübergreifende Analyse bereitgestellt, die auch maschinelle Übersetzung erleichtern kann.

1 Introduction

This paper takes up an old debate and proposes a solution based on an implementation for German (IMS, Stuttgart), French (RANK Xerox, Grenoble), and English (Xerox PARC, Palo Alto) within the cooperative parallel grammar development project PARGRAM: are auxililaries simply main verbs with special properties (Gazdar et al. (1982), Pullum and Wilson (1977), Ross (1967)), or should they instantiate a special category AUX (Akmajian et al. (1979), Chomsky (1957))? In current lexical approaches, for example, Lexical-Functional-Grammar (LFG) and Head-driven Phrase Structure Grammar (HPSG), auxiliaries (e.g. *have*, *be*) and modals (e.g. *must*, *should*) have traditionally beeen treated as *raising* verbs, which are marked as special in some way: in HPSG through an [AUX: +] feature (Pollard and Sag 1994),[1] in LFG (Bresnan 1982) by

[1] Newer work in HPSG on French (e.g., Abeillé and Godard (1994)) and Italian (Monachesi (1995)) has moved away from this particular implementation, instead relying on the mechansism of *argument composition* first introduced by Hinrichs and Nakazawa (1990) for German. While these approaches advocate a "flat" representation of auxiliaries, they do so at the level of phrase structure. A hierarchical relationship between auxilaries and main verbs (com-

a difference in PRED value. Newer work within LFG (Bresnan (1995), T.H. King (1995)) has been moving away from the raising approach towards an analysis where auxiliaries are elements which contribute to the clause tense/aspect, agreement, or voice information, but not a subcategorization frame.[2] This view is also in line with approaches within GB (Government-Binding), which see auxiliaries simply as possible instantiations of the functional category I (e.g., Roberts (1983, 1985) for some early formulations), and in fact reverts to a traditional view that considers auxiliaries as simple morphological markers.[3]

In LFG, morphology and phrase structure are considered loci of language variation, while information about grammatical functions (f-structure) and semantics (σ-structure) is considered a more crosslinguistic invariant. In order to construct analyses as *parallel* as possible for each of the languages (English, French, German) we adopt and expand on the newer directions within LFG in that we treat auxiliaries as functional elements, not as raising verbs. This allows parallel representations for sentences which would yield varying structures for each of the three languages under the raising analysis (see section 3.1). One very obvious advantage of such parallel analyses lies in the area of machine translation (MT), another in the subsequent construction of semantic representations for tense and aspect (see section 3.2).

The invariant contribution of auxiliaries to (complex) tense is modeled in a crosslinguistically realistic manner at the level of f(unctional)-structure, while language particular, idiosyncratic syntactic properties (e.g. number of auxiliaries involved, VP-deletion, VP-fronting) continue to be handled by phrase structure rules. In addition, morphological wellformedness conditions imposed by an auxiliary on its "dependents" are modeled at a further level of projection *m(orphological)-structure*. Our implementation thus combines the advantages of the older analyses on which LFG (Bresnan 1982, Falk 1984) and HPSG (Pollard and Sag 1994) treatments of auxiliaries are based, while abstracting away from the particular realization of tense: whether it be periphrastic (auxiliaries), or morphological, the f-structure representation of tense is parallel.

2 The Formalism

We assume here the "traditional" LFG architecture of Bresnan (1982), as well as the newer advances within the theory (Dalrymple et al. (1995)). A grammar is viewed as a set of *correspondences* expressed in terms of *projections* from one level of representation to another. Two fundamental levels of representation

plements) is maintained (COMPS) and arguments from the main verb are inherited by the auxiliaries. This approach must thus be regarded as a variant the original raising analysis, in contrast to the more radical approach implemented here.

[2]See Falk (1984) for an early LFG treatment of 'do' in line with that proposed here and Niño (1995), Ackerman (1984, 1987) for related argumentation. However, these approaches do not deal with the implementational challenge of formulating morphological wellformedness conditions that arise as a consequence of a non-raising approach (see section 3.2).

[3]See, for instance, Wagner and Pinchon (1991) for French.

within LFG are the c(onstituent)-structure and the f(unctional)-structure. The c-structure encodes idiosyncratic phrase structural properties of a given language, while the more universal f-structure provides a representation of information on grammatical functions (e.g. SUBJect, OBJect) and complementation, and allows the statement of general conditions on tense, binding, etc. The correspondence between c-structure and f-structure is not onto or one-to-one, but many-to-one, allowing an abstraction over idiosyncratic c-structure properties of a language (e.g. discontinuous constituents).

The grammars are implemented using the *Xerox Linguistic Environment* (XLE)[4], which allows the integration of the projection-based architecture of LFG (Dalrymple et al. 1995) and the correspondence-based MT approach of Kaplan et al. (1989).[5]

3 Auxiliaries — a flat approach

3.1 The Received Wisdom

The traditional treatment of auxiliaries in both HPSG and LFG has its roots in Ross's (1967) proposal to treat auxiliaries and modals on a par with main verbs.[6] In particular, auxiliaries are treated as a subclass of raising verbs (e.g. Pollard and Sag (1994), Falk (1984)). The simple English sentence (1) would correspond to the c-structure and f-structure in (2) and (3), respectively. The level of embedding in the f-structure exactly mirrors the c-structure: each verbal element takes a complement. The German representation is similar, but French has one level of embedding less (see (4), (5)). Thus, simple sentences which are predicationally equivalent are represented by diverging f-structures.

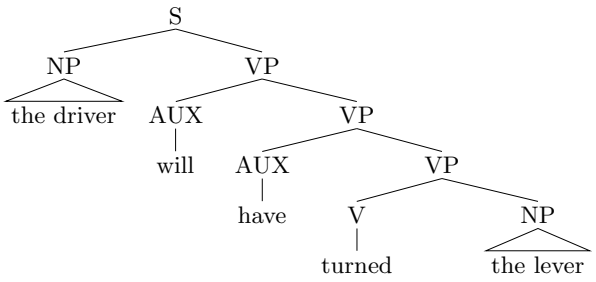
(1) The driver will have turned the lever
Der Fahrer wird den Hebel gedreht haben (German)
Le conducteur aura tourné le levier (French)

[4]See Kaplan and Maxwell (1993) for a description of XLE's predecessor, the *Grammar Writer's Workbench*.

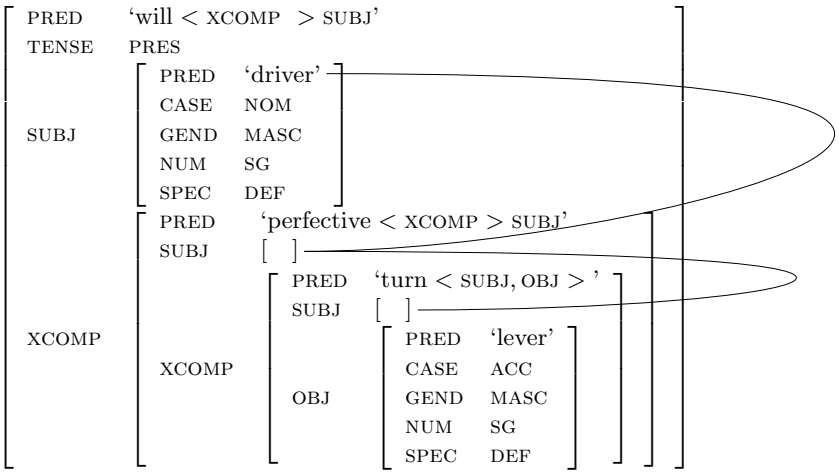
[5]See also Sadler et al. (1990), Sadler and Thompson (1991), Kaplan and Wedekind (1993) for further work on MT within LFG.

[6]The term *auxiliary* has often been taken to subsume both modals and elements such as *have* and *be*. However, the distinction between the two is necessary not only semantically, but also syntactically. In German (and some dialects of) English modals can be stacked, while the distribution of auxiliaries is more restricted. Also, assuming that semantic interpretation is driven primarily off of the f-structure, the relative embedding of modals must be preserved at that level in order to allow an interpretation of their scope and semantic force.

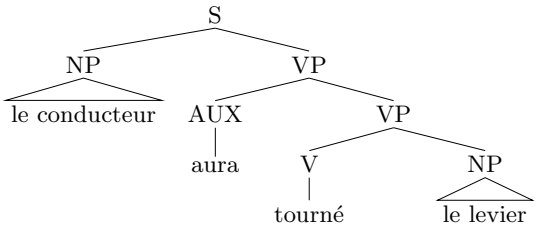
(2)


S
NP
VP
the driver
AUX
VP
will
AUX
VP
have
V
NP
turned
the lever

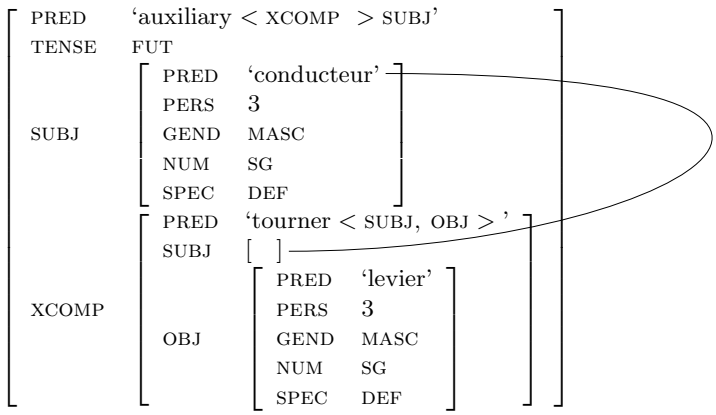
(3)


PRED 'will < XCOMP > SUBJ'
TENSE PRES
SUBJ
PRED 'driver'
CASE NOM
GEND MASC
NUM SG
SPEC DEF
XCOMP
PRED 'perfective < XCOMP > SUBJ'
SUBJ [ ]
XCOMP
PRED 'turn < SUBJ, OBJ > '
SUBJ [ ]
OBJ
PRED 'lever'
CASE ACC
GEND MASC
NUM SG
SPEC DEF

(4)


S
NP
VP
le conducteur
AUX
VP
aura
V
NP
tourné
le levier

(5)



The main reasons to treat auxiliaries as complement taking verbs in English are: 1) an account of VP-ellipsis, VP-topicalization, etc. follows immediately; 2) restrictions on the nature of the verbal complement (progressive, past participle, etc.) following the auxiliary can be stated straightforwardly (Pullum and Wilson (1977), Akmajian et al. (1979), Gazdar et al. (1982)). There are also major reasons, however, for not adopting this analysis: 1) linguistic adequacy; 2) unmotivated structural complexity; 3) non-parallel analyses for predicationally equivalent sentences.

As already argued by Akmajian et al. (1979), crosslinguistic evidence indicates that elements bearing only tense/aspect, mood, or voice should belong to a distinct syntactic category. In languages like French the information carried by *will* (future), or *have* (perfect) in (1) is realized morphologically rather than periphrastically. The analyses in (3) and (5) thus effectively claim that there exists a deep difference in the predicational structure of auxiliaries like *will* and *have* and the French *aura*. The f-structures for English and German posit one more XCOMP than the French in the overall subcategorization frame. This is not desirable from a crosslinguistic point of view, nor is it helpful for MT. Finally, for French, there is also language internal evidence based on clitic placement that argues against the treatment of auxiliary elements as raising verbs (Abeillé and Godard (1994)).

3.2 Alternative Implementation

The approach adopted here is a *flat* analysis of auxiliaries at f-structure (6).

(6)

$$\begin{bmatrix} \text{PRED} & \text{'turn/drehen/tourner} < \text{SUBJ, OBJ} > \text{'} \\ \text{TENSE} & \text{FUTPERF} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{'driver/Fahrer/conducteur'} \\ \text{CASE} & \text{NOM} \\ \text{GEND} & \text{MASC} \\ \text{NUM} & \text{SG} \\ \text{SPEC} & \text{DEF} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{'lever/Hebel/levier'} \\ \text{CASE} & \text{ACC} \\ \text{GEND} & \text{MASC} \\ \text{NUM} & \text{SG} \\ \text{SPEC} & \text{DEF} \end{bmatrix} \end{bmatrix}$$

The f-structures for French, German, and English here are fully parallel. The language particular differences in the number of auxiliaries are represented at c-structure. The contribution of the auxiliaries to the overall tense is still reflected at f-structure,[7] but they do not subcategorize for complements. Structural phenomena like VP-ellipsis, coordination, or topicalization can, however, still be accounted for by an appropriate embedding at c-structure (cf. (2) and (4)).[8] This adequately models the role of auxiliaries in natural language, in particular with regard to a more realistic treatment of tense (compare (3), (5) and (6)).

However, the flat f-structure in (6) provides no room for a statement of selectional requirements, allowing massive overgeneration (e.g. nothing blocks the presence of two *have* in (2)). Neither can the particular order of auxiliaries be regulated. Our solution takes advantage of LFG's flexible projection-based architecture by implementing a projection which models the hierarchical selectional requirements of auxiliaries, yet does not interfere with the subcategorizational properties of verbs, as would be the case under a raising analysis.

A Projection for Morphological Forms

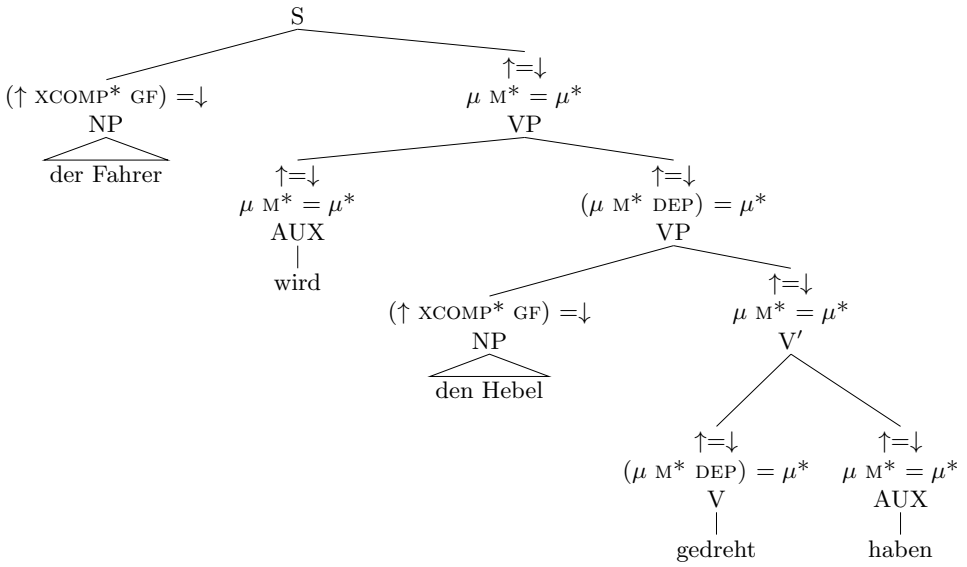
The view of auxiliaries as raising verbs is particularly costly for German. In LFG, the flexible word order of German is handled via *functional uncertainty*, which characterizes long-distance dependencies without resorting to movement analyses (Netter (1988), Zaenen and Kaplan (1995)). As in (7), which illustrates

[7] The construction of the value for the composed tenses results from a complex interaction between the lexical entries. Alternatively to this solution of "collapsing" the contribution of syntactically independent auxiliaries, one could envision decomposing the French *aura* into a *will* and *have* and thus telescoping the French f-structure so that it is parallel to that of the English and German. However, this is clearly an undesirable solution. For one there is no solid linguistic motivation for this approach. For another, an ugly computational problem arises in that arguments must then be "filled in" for the newly created layer of f-structure (Maxwell/Newman (p.c.)).

[8] As is well known, English *will* has the syntactic properties of a modal, rather than that of an auxiliary. This fact is reflected in terms of c-structure.

our alternative solution, functional uncertainty is represented by the Kleene Star (XCOMP*). The annotation on the NPs indicates that they could fulfill the role of any possible grammatical function (GF), e.g. SUBJ or OBJ, and that the level of embedding ranges from zero to infinite. With every auxiliary subcategorizing for an XCOMP, the two NPs could conceivably be arguments of three different verbs: *wird*, *haben*, or *gedreht*. Thus, the greater structural complexity unnecessarily increases the search space for the determination of a verb's arguments.

(7)



As discussed, we posit no subcategorization frame for auxiliaries, but rather propose projecting a further level of representation from the c-structure, the m-structure (following a suggestion by Kaplan (p.c.)).

Like the f-structure, the m-structure is an attribute-value matrix. It encodes language-specific information about idiosyncratic constraints on morphological forms. In "traditional" LFG this kind of information appears at f-structure, despite being mostly unrelated to the grammatical relations and function-argument structure the f-structure is intended to encode. The annotation μ M* in (7) refers to the m-structure associated with the parent c-structure node, and μ^* refers to the m-structure associated with the child node.[9] The m-structure corresponding to the matrix VP in (7) is (8). The desired flat f-structure resulting from the usual ↑ and ↓ annotations is as in (6).

[9]The more familiar ↑ and ↓ of LFG are simply shorthand notations of the same idea, but restricted to the projection from c-structure to f-structure: ↑= ϕ M*, ↓= ϕ *. NOTE THAT THE '*' IN THIS NOTATION IS NOT EQUIVALENT TO THE KLEENE STAR IN 'XCOMP*'.

(8)

$$m-structure\left[\begin{array}{lll}\text{AUX} & + & \\ \text{FIN} & + & \\ \text{DEP} & \left[\begin{array}{lll}\text{AUX} & + & \\ \text{FIN} & - & \\ \text{VFORM} & \text{BASE} & \\ \text{DEP} & \left[\begin{array}{lll}\text{FIN} & - & \\ \text{VFORM} & \text{PERFP} & \end{array}\right] & \end{array}\right] & \end{array}\right]$$

The m-structure is not derived from the f-structure. Rather, both representations are in simultaneous correspondence with the c-structure. The following (abbreviated) lexical entries exemplify the pieces of information contributed by each verbal element. The disjunctive lexical entry for *wird* 'will' takes the various combinatory possibilities of auxiliaries and main verbs into account, and provides the appropriate tense feature. In (9), the second disjunct for *wird* requires that the embedded VFORM be BASE, that there be no passive involved, and that the next embedded verbal element, the main verb, be a perfect participle. The auxiliary *haben* in turn requires that its dependent be a perfect participle, and that it be unergative (via *constraint equations*: $=_c$).[10]

(9) wird AUX
$(\uparrow \text{SUBJ CASE}) = \text{NOM}$
$(\uparrow \text{SUBJ NUM}) = \text{SG}$
$(\mu\ \text{M}^*\ \text{AUX}) = +$
{ $(\mu\ \text{M}^*\ \text{DEP VFORM}) =_c \text{BASE}$
$(\mu\ \text{M}^*\ \text{DEP DEP VFORM}) \neq \text{PERFP}$
$(\uparrow \text{PASSIVE}) \neq +$
"simple future: wird drehen"
$(\uparrow \text{TENSE}) = \text{FUT}$
|
$(\mu\ \text{M}^*\ \text{DEP VFORM}) =_c \text{BASE}$
$(\mu\ \text{M}^*\ \text{DEP DEP VFORM}) =_c \text{PERFP}$
$(\uparrow \text{PASSIVE}) \neq +$
"future perfect: wird gedreht haben"
$(\uparrow \text{TENSE}) = \text{FUTPERF}$ }

(10) haben AUX
$(\mu\ \text{M}^*\ \text{AUX}) = +$
$(\mu\ \text{M}^*\ \text{VFORM}) = \text{BASE}$
$(\mu\ \text{M}^*\ \text{FIN}) = -$
$(\mu\ \text{M}^*\ \text{DEP VFORM}) =_c \text{PERFP}$
$(\uparrow \text{VSEM}) =_c \text{UNERG}$
$(\uparrow \text{PASSIVE}) \neq +$

[10]Lexical semantic information such as the unergative nature of a verb does not correlate with its *morphological* form, and is not modeled at m-structure. The distinction between unergative and unaccusative verbs is needed for auxiliary selection in German and French.

(11) gedreht V (↑ PRED =) 'drehen< SUBJ, OBJ>'
(μ M* VFORM) = PERFP
(μ M* FIN) = −
(↑ VSEM) = UNERG

Statements about "morphological" dependents (DEP) are thus decoupled from functional uncertainty: the relation of NP arguments to their predicator now does not extend through various layers of linguistically artificial structural complexity (XCOMPs). The assumption of an m-structure can also be extended effectively to other parts of the grammar. Language particular morphological wellformedness conditions on adjective inflection or relative pronoun agreement, for example, can now be stated on the m-structure as idiosyncratic, language particular information which can be ignored for purposes of MT or semantic interpretation.

Long Distance Dependencies

Note that functional uncertainty *per se* is not the central problem, nor is it the motivating factor for the adoption of an m-structure. For flexible word order languages like German, the association of NP arguments with their predicators must be resolved within any implementation. Our approach reduces structural complexity at the level of subcategorization frames regardless of the precise framework.

VP-topicalization as in (12) or extraposition, however, still require an unbounded long-distance dependency to be assumed.

(12) [Den Hebel gedreht] wird der Fahrer haben
the.Acc lever turn.PPart will.Pres.Sg the driver have.Inf
'The lever turned, will have the driver.'

The overall gain remains considerable though, as the functional uncertainty is distributed only over the m-structure of the verb complex ((μ M* DEP*) = μ*), and does not involve the resolution of the role of NP arguments in cases like (13) and (**??**) where there is only one main predicator (for example, no modals).

Morphosyntactic vs. Semantic Tense

Note that this treatment of auxiliaries does not as yet include a fine-grained represention of tense and aspect, but does provide the basis needed for a thorough crosslinguistic analysis of tense and aspect. For example, while the particular morphosyntactic of future perfect may differ from language to language and not always be entirely equivalent in its semantic interpretation, the very fact that the morphosyntactic information has been encoded in a systematic and easily accessible fashion for a particular language opens the door for a subsequent semantic analysis of tense. For example, the German present tense corresponds both to the English present progressive and the English future. The German

perfect corresponds to both the English perfect and the English simple past. These correspondences are semantic in nature and require an analysis in terms of, for example, relative relations between *Speech*, *Event* and *Reference* times (Reichenbach (1947)) as discussed, for example, in Kamp and Reyle (1993). Consider the future perfect of (**??**). The speech time (S) is assigned a given value on a time line. The reference time (R) must follow the speech time (S < R), but the event time (E) must precede the reference time (E < R): S < E < R.

In this case, the semantic evaluation will be parallel in German, French and English. In a case like (13), on the other hand, it is only the semantic interpretation of the entire clause, rather than a simple evaluation of the morphological tense/aspect information which allows a correct semantic interpretation of the English present progressive as a future.

(13) I am flying to Boston tomorrow.

However, collecting and registering the morphosyntactic temporal information of a given language in a simple, standardized encoding in terms of a single feature which is easily accesible provides the necessary basis for the further construction of a deeper semantic representation that can be truly considered to be language universal.

4 Conclusion

In the spirit of LFG, our analysis of auxiliaries in English, French, and German factors out language specific information from crosslinguistically general f-structure information through the use of a separate level of representation, the m-structure. Features needed only to ensure language particular wellformedness are no longer unified into the f-structure, cluttering a representation that is meant to be language independent. In our analysis, only features needed for further semantic interpretation, MT, or for the expression of language universal syntactic generalizations are represented at f-structure. For example, morphologically encoded information like case, gender, or agreement is needed for statements as to binding, predicate-argument relations, or the determination of complex clause structures (given that agreement is generally clause-bounded). The solution allows a language universal 'flat' f-structure analysis for auxiliaries and complex tenses, while enforcing idiosyncratic wellformedness conditions at another level of representation. We claim that the rules necessary for semantic interpretation or MT between languages do not need to know whether tense was encoded by an affix or by a full auxiliary. Indeed, the analyses proposed facilitate the task of MT and provide a solid basis for subsequent semantic interpretation.

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