

Linguistics and Machine Translation

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Abstract

This talk discusses some of the challenges posed for theoretical linguistics by translational problems. It briefly discusses different aspects of the concept of translational equivalence and the degree to which this relation may be captured by machine translation (MT) systems. It is argued that the formal requirements and multilingual perspective of MT provide new criteria of adequacy for semantic theories. This motivates further development of linguistic semantics as a prerequisite for a semantically based theory of machine translation. In particular it seems that the semantics of translational equivalence needs to be able to refer to a typology of linguistic objects as part of its "ontology". Some of the points are illustrated by a short presentation of an experimental MT project. Finally it is briefly indicated how the treatment of linguistic objects as part of the semantic model fits into a situation theoretic account.

1. Translational Equivalence as Empirical Evidence

At least one optimistic thing can be said about the relationship between linguistics and MT: it is improving. There was a time when the two concepts were rarely conjoined, and if they were, 'but' seemed a more plausible conjunction than 'and'. To-day, however, both fields have changed somewhat: linguistic theories of grammar tend to take problems of computational tractability seriously, and linguistic approaches are finding their way not only into small experimental MT projects but also into the large market-oriented ones.

Within this area of increased interaction between the two fields the flow of information – or inspiration – is usually seen as unidirectional: linguistic theories of syntax and semantics provide representational tools for the developers of MT systems, but remain rather unperturbed by the activity themselves. However, the increased contact between linguistics and the activity of translation should not be seen as a pure case of applied science, in which results from linguistics are simply used to solve practical problems. Translation should also be recognized as an important testing ground for linguistics, reinforcing a much-needed multilingual perspective in the development of more or less formal linguistic theories. Specifically, the "pre-theoretic" concept of translational equivalence may provide valuable criteria of adequacy for linguistic theories. This is especially evident within semantics. Within linguistic semantics we try to characterize the meaning of a linguistic expression by translating it into some meaning representation. This meaning representation is, basically, just another linguistic expression, and the natural question is how this alternative expression brings us closer to the characterization of meaning than did the original expression. There are several relationships a meaning representation may enter into which may

motivate it as an informative characterization of meaning. For one thing we may relate it to different expressions within the same language, for instance by means of a model theoretic interpretation, thereby characterizing various semantic relations like synonymy, entailment etc. between expressions; for another the meaning representation can be used to mediate between language and other contacts with reality, like sight and action; for yet another the representation can be related to expressions in different languages, and hence characterize semantic relations across language borders. The relation of translational equivalence involves just this last-mentioned type of semantic relations and hence constitutes an empirical domain with respect to which semantic representations need to be adequate. The relation of translational equivalence is not easy to pin down, but a corpus of actual texts paired with their translations, sorted according to quality by bilingual informants, would be a starting point, giving us part of the extension of the relation, so to speak. The translational relation is manifested in such a collection of actual translations. To the extent that semantic representations *are* adequate with respect to such phenomena – that is, to the extent that they classify equivalent expressions together – they are also motivated as something more than just arbitrary alternative encodings of some semantic content.

It is an age-old insight that translational equivalence involves much more than denotational equivalence. (I am leaving aside now the important question of whether the translation relation should be conceived as an equivalence relation at all; we may note that good translation is frequently assumed to be irreversible.) The literature on translation discusses several sub-species of the relation; the following categories are suggested by Werner Koller (1983:186ff.):

1. *Denotational equivalence*
2. *Connotative equivalence*
3. *Text-normative equivalence*
4. *Pragmatic equivalence*
5. *Formal equivalence*

Denotational equivalence means equivalence with respect to properties of a described situation (conceived as a section of “objective reality”). However, languages usually allow alternative verbalizing strategies, which may induce different *perspectives* on what may still be conceived as the same described situations, highlighting different aspects of their temporal structure or of the relationships between their participants. (Example: “I can only stay until 5 PM” vs. “I have to leave at 5 PM”.) Similarly, alternative verbalizations may belong to different sub-languages or levels of style. Equivalence with respect to such properties is *connotative* equivalence. *Text-normative* equivalence is equivalence with respect to properties characteristic of certain text types. A French business letter may have a different structure from a Norwegian business letter; a French/Norwegian pair of letters are text-normatively equivalent only if they each satisfy the respective French and Norwegian conventions for such texts. *Pragmatically* equivalent texts or utterances are equivalent with respect to the communicative acts performed with them, and their effects on the receiver (such as the degree of politeness accompanying a request, irony, etc.). Cultural differences frequently make the achievement of pragmatic equivalence difficult. Finally, *formal* equivalence is equivalence with respect to properties of assonance, rhyme, rhythm and word-play.

Obviously, all these types are not always of equal importance, but they all belong in a principled discussion of translational equivalence. We may note that denotational equivalence primarily concerns the described situation, pragmatic equivalence the discourse situation, whereas connotative, text-normative and formal equivalence primarily concern, in an irreducible way, *the linguistic signs themselves*. If two texts are equivalent with respect to chosen perspectives, levels of style, text-structural norms and metrical properties, they can be said to be equivalent with respect to the *types of linguistic devices* used in them. This suggests that a precise characterization of translational equivalence presupposes not only adequate denotational semantics and pragmatics enabling us to

refer to such properties of described situations and discourse situations which translationally equivalent expressions have to bear a common relation to. It seems that we also need a universal typology of linguistic devices: linguistic expression types themselves are an irreducible part of the 'ontology' of things which translationally equivalent expressions have to have in common. Thus, formal aspects of a text may create types of meaning that we want to re-create in a translation. If we take it as axiomatic that it is the task of semantics to account for all aspects of meaning, these translational phenomena bring new problems within the scope of semantic theories.

2. Limits of MT: Equivalence from Pre-Established Correspondences

Translational equivalence is basically a relation between *texts* or *utterances* rather than between lexical and grammatical elements in language descriptions. In other words, translational equivalence concerns *parole* rather than *langue*. It is an analytic task to reduce translational equivalence between texts, as far as possible, to a function of correspondence relations between elements of language descriptions – to relations of *langue* rather than *parole*. However, it seems very likely that there are types of translational equivalence that cannot be so reduced. Thus, while connotative properties of individual lexemes might be given some representation in the lexicon, it is difficult to see how information about connotative and stylistic properties of complex phrases can be derived compositionally, in the way information about denotative properties are. In such cases the only solution seems to be to list such complex phrases with their properties as idioms, but extensive use of this solution is at least impractical because it leads to an explosion in the inventory of idioms. Furthermore, global stylistic properties of texts that concern, for instance, the frequency of certain constructions cannot even in principle be reduced to simple correspondence relations between linguistic descriptions. There are also aspects of formal translational equivalence (for instance, in translations of poetry) and culture-bound pragmatic equivalence that seem to presuppose genuine creativity on the part of the translator, and hence to be something that cannot be reduced to pre-established correspondences.

These limitations are at the same time limitations on the possibility of machine translation. A machine translation system is possible to the extent that we have been able to reduce aspects of translational equivalence to functions of pre-established correspondence relations between finite linguistic descriptions. The linguistic analysis in the descriptions may show any degree of sophistication, and we may grant the possibility that the translation algorithm is able to exploit contextual information of various kinds to choose among alternatives – the fact remains that any equivalence between texts established by the system must be compositionally derivable from the elements in the descriptions and the pre-established correspondence relations between them. This holds true whether we implement the relations as simple pointers or as representations of some kind, representing what the corresponding entities have in common. Such representations, if we use them, can reasonably be seen as semantic representations. Since it seems plausible to claim that all aspects of translational equivalence are meaning related, it should be the task of semantics to account for the correspondence relations between languages on which translational equivalence is based. Semantic representations, then, should capture whatever a translational equivalent has to be equivalent with respect to, to the extent that this is derivable from the linguistic descriptions. Such representations are at the same time potential *interlingua expressions* – it should in principle be possible to implement a translation algorithm that translates a source text to such a representation, and generates a target text from it.

3. Interlingua as a Theoretical Tool

This does not mean that it would be a good idea to do so in practice. The majority view is that the transfer technique is to be preferred over the interlingua technique, and there are often good arguments to support this view. The goal of constructing a true interlingua is often considered as unrealistic, or at least impractical. Such a universal intermediate representation is easily seen at least as a detour; in many cases it seems simpler to define direct transitions from source representations to target representations. Still, the idea of an interlingua should not be discarded out of hand. In the first place, the possibility of interlingua-based translation does not imply the possibility of a truly universal interlingua, common to all conceivable language pairs. An interlingua can be specific to a given language pair and still be an interlingua. In the second place, we should distinguish between the theoretical *possibility* of an interlingua and the *practical utility* of having such an interlingua actually implemented in a system. Even if we decide against the latter, working out an interlingua might be a useful part of a principled study of translational equivalence. In fact, on reflection it is easily seen that the distinction between interlingua and transfer is not a deep distinction of principle, but rather a fairly superficial one of implementation. It is never the case that transfer must be preferred over interlingua because transfer is the only *possible* option: interlingua is possible whenever transfer is. Machine translation actually implies the possibility of interlingua-based machine translation. This is because machine translation, as I have already pointed out, is only possible to the extent that translational equivalence can be reduced to a function of pre-established correspondences between elements of two language descriptions. Since the language descriptions are finite, there will be a finite number of such pre-established correspondences. The correspondences can be implemented as simple pointers, but it is of course also possible to label each correspondence with a unique name, and to write rules for combining such labels compositionally in tandem with the rules for combining the corresponding expressions syntactically. In short, the correspondence relations, being finite in number, can evidently be described in a metalanguage. Such a metalanguage would be a theoretically possible interlingua between the two languages, and even if we don't implement it as an interlingua the metalanguage might be a useful theoretical tool for keeping our ideas straight while writing the programs.

4. The PONS Project: Exploiting similarity between languages

Now, I haven't worked out such a theoretically interesting interlingua yet. I have, on the other hand, been working on an experimental translation system, and I should like to give a brief sketch of it in order to illustrate some of the points I have made. The project is called PONS – acronymic for “Partiell Oversettelse mellom Nærstående Språk” (Partial Translation between Closely Related Languages). The starting point was an idea about studying some aspects of the relationship between linguistic motivation and computational tractability in MT systems. A common objection to linguistically sophisticated language descriptions as modules in translation systems is that they will inevitably make analysis and synthesis hopelessly redundant and inefficient, compared to quick ad-hoc shortcuts from source construction to target construction, without regard for their full set of grammatical and semantic properties. This is evidently a valid consideration – it would be irrational to spend time finding a lot of grammatical and semantic information if you really don't need it. On the other hand, linguistic motivation and computational tractability could be combined if we could achieve a linguistically well-informed system able to refrain from using all its knowledge all the time. If the system had some means of evaluating the complexity of a given translational task in advance, it could infer the amount of analysis required and adjust its mode of operation accordingly. The possibility of taking shortcuts would obviously be most frequent during translation between closely related languages; hence it was natural to try out these ideas in relation to translation between

a pair of Scandinavian languages like Norwegian and Swedish. The formal tools of unification grammar seemed well suited to the task, since feature structures can be more or less underspecified: information can be removed from them as the need arises.

It is not only considerations of efficiency that motivate such an attempt to achieve a system that uses its knowledge in a considered way. It seems quite plausible to assume that human translators behave in a similar manner. We seem able to adapt the amount of information we bring to bear on a problem to its complexity. Thus it is obviously far easier for us to translate between closely related languages than between languages that are genetically and typologically further apart. The Scandinavian languages are almost limiting cases in this respect. In translations between Danish, Swedish and Norwegian, or between Bokmål and Nynorsk, there will frequently (but far from always, of course) be a word-by-word type correspondence between source and target texts. A natural procedure in such cases would be first to inspect the sentence to be translated sufficiently closely to determine that it contains no constructions departing from the unmarked word-by-word case, and then translate word-by-word, making morphological adjustments along the way. The human translator would not take the trouble to reflect carefully and at length on the content and connotations of the source sentence, in abstraction from its syntactic form, and then try to encode this content "from scratch" in the target language with no regard for the way it was expressed in the source text. Only to the extent that the constructions do not allow fairly simple formal mappings is such a closer consideration of semantic properties necessary. The translator will use as much of the structure of the source sentence as possible – as long as she can trust that a similar sentence structure in the target language is translationally equivalent. And this is not a case of laziness; it is because this method is a precondition for a good translation, that is, a translation which renders the properties of the source text as reliably as possible, *including its way of using language*. By "a way of using language" I have in mind production of the type of meaning which is captured by connotative equivalence (such as equivalence with respect to the chosen perspective on a situation), pragmatic equivalence and formal equivalence. Languages have different resources, different device inventories, for creating such meaning – that is what makes translation difficult – but the more closely two languages are related, the greater the overlap between their inventories of linguistic devices will be. It is not a facile shortcut, but the satisfaction of an independent purpose of translation which takes place when we choose equivalent linguistic devices in a translation – for instance word-by-word translation whenever that is possible. ('Possible' here means 'preserving translational equivalence' – including connotative equivalence etc. In other words, it is not a counter-argument to the claim made here that word-for-word translations frequently are bad – when they are bad, they presumably are not the closest possible equivalent.) In such cases we pass directly from a device in one language to an equivalent device in the other; careful consideration of the actual job done by these devices is superfluous. This does not mean that meaning suddenly is unimportant, it simply means that equivalence of meaning has been established once and for all, given our knowledge of the relationship between the languages, and therefore we need not worry about it every time.

Hence there are both practical and theoretical reasons to try to develop a system able to take "shortcuts" past an involved semantic analysis whenever this is possible because of a certain degree of structural correspondence between the two languages. This is a basic idea in the PONS project. The system is implemented (in Interlisp), except for a few modules that are not fully integrated yet. The linguistic descriptions are developed within an extended and modified version of Lauri Karttunen's D-PATR, a framework for developing unification-based grammars. The idea of shortcuts is captured by a distinction between three different modes of operation, corresponding to three different degrees of correspondence between source and target constructions. We will look at the most elaborate mode, Mode 3, first.

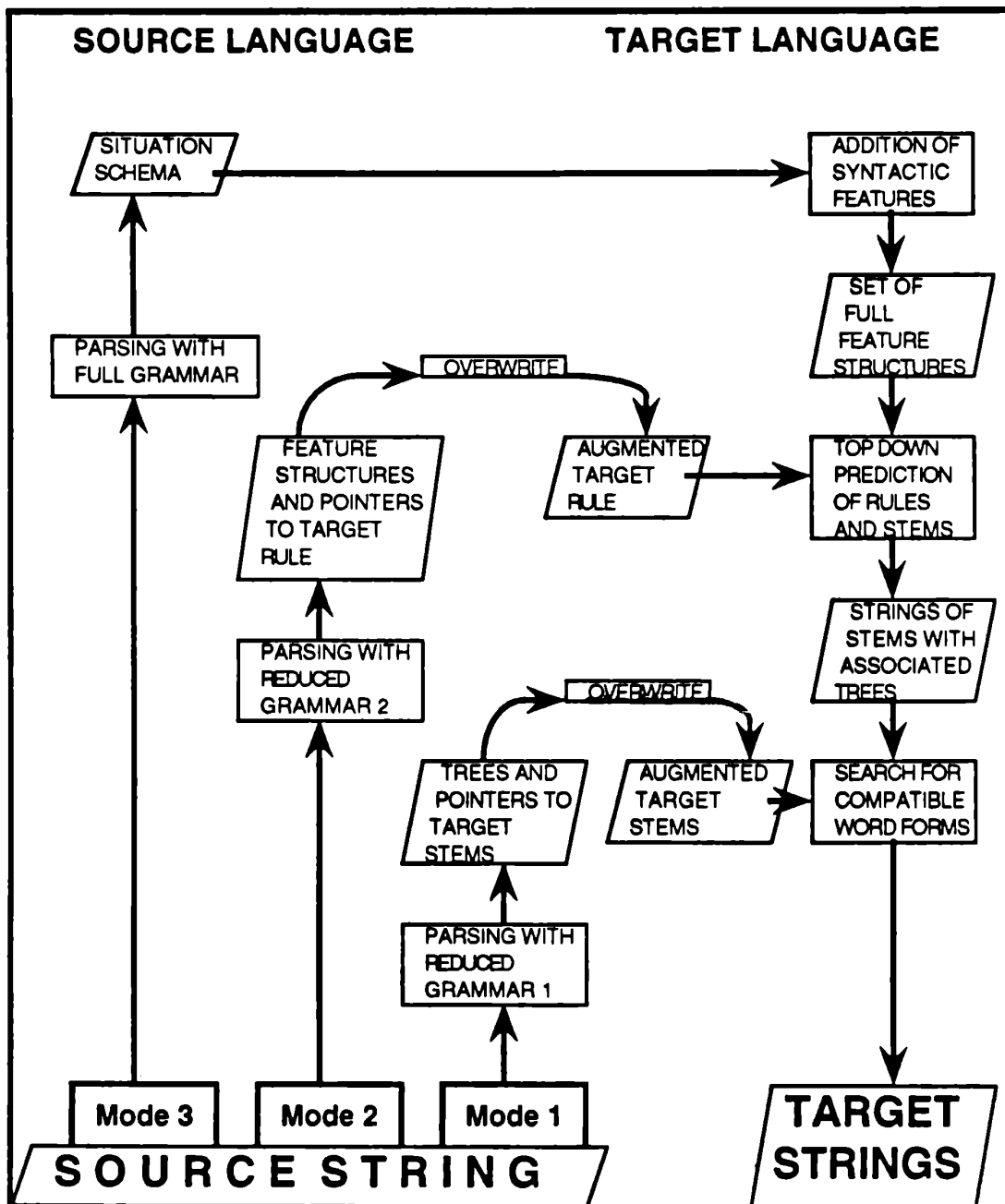


Fig. 1. The three modes of PONS

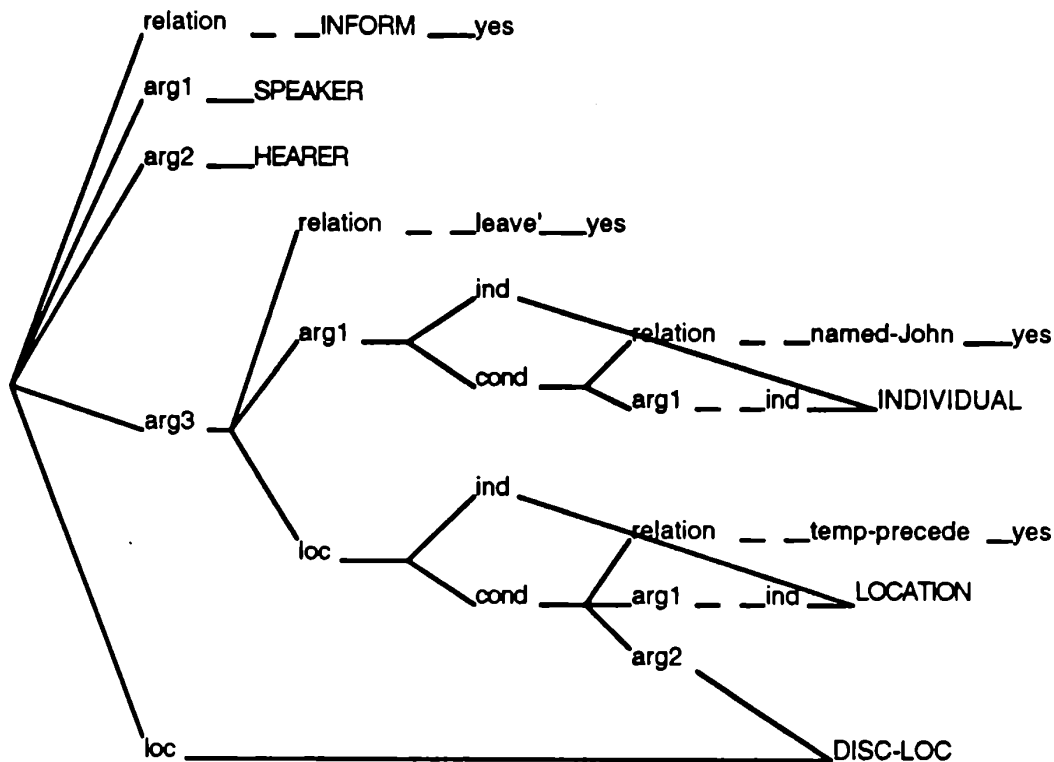


Fig. 2 Situation schema, PONS version

5. Mode 3: Semantic Representations as Interlingua

The Mode 3 path from source string to target strings is described in the outer circle of fig. 1. The language description on which parsing is based consists of a set of annotated phrase structure rules, a set of stems, in which each stem contains all information which is common to all forms of that stem, and a set of word forms containing further information. All entities – rules, stems and word forms – are represented as feature structures, or directed graphs, which are unified during parsing. The result of a parse is a phrase structure tree and a feature structure. The feature structure consists of substructures, one of which is a semantic representation in the form of a *situation schema* (fig. 2).

The situation schemata I am using are somewhat modified versions of the situation schemata introduced by Fenstad, Halvorsen, Langholm and van Benthem in 1987. A situation schema is a representational format suited to be interpreted by situation theory. In Situation Semantics the meaning of a sentence is conceived as a relation between types of discourse situations and types of described situations: the meaning constrains these situations to be of certain types. The example in fig. 2 represents the sentence "John left". In the schema attributes represent parameters of situations (a situation is constituted of a *relation*, a set of *arguments* to it and a *location*, among other things),

while values represent the corresponding entities in the situations represented. The “outermost layer” represents aspects of the discourse situation, while the described situation is entered as the value of *arg3* (it is the entity about which the speaker informs the hearer).

In the full feature structure of a sentence the situation schema is inter-related with the syntax substructure in various ways. Fig. 3 shows the basic layout of full feature structures, while fig. 4 shows a simplified example.

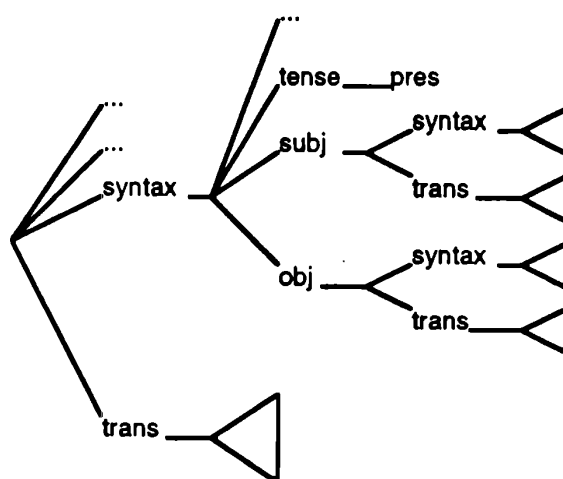


Fig. 3 Basic layout of PONS feature structures

The patterns of unifications between the syntax and semantics substructures express such things as linking relations between syntactic functions and semantic argument positions. In Mode 3 the situation schema is extracted as a kind of interlingua expression from the feature structure. In other words, linking relations and other syntactic information from the source string parse are forgotten about, since they are source language specific. Target strings are then generated from the situation schema, on the basis of the target grammar, in three stages (cf. fig. 1, right-hand column of boxes):

1. Target stems expressing the relation values in the schema are retrieved from the lexicon, and their feature structures are unified into the situation schema. The result is that target language specific syntactic features are added, giving a set of full feature structures, linking relations and all, as output.
2. Syntactic rules are predicted top-down, the predictions being constrained and governed by the information in the feature structures, which in a sense “know all about” the constructions about to be generated. The output is a set of trees, with lexical stems at the terminal nodes.
3. Word forms are entered at the terminal tree nodes, to the extent that their feature structures are compatible with what is already there. The output is a set of target strings – the set of strings, that is, to which the target grammar assigns situation schemata compatible with the source situation schema. To the extent that I have been able to capture the properties that define translational equivalence in the situation schemata, the strings are useful translations.

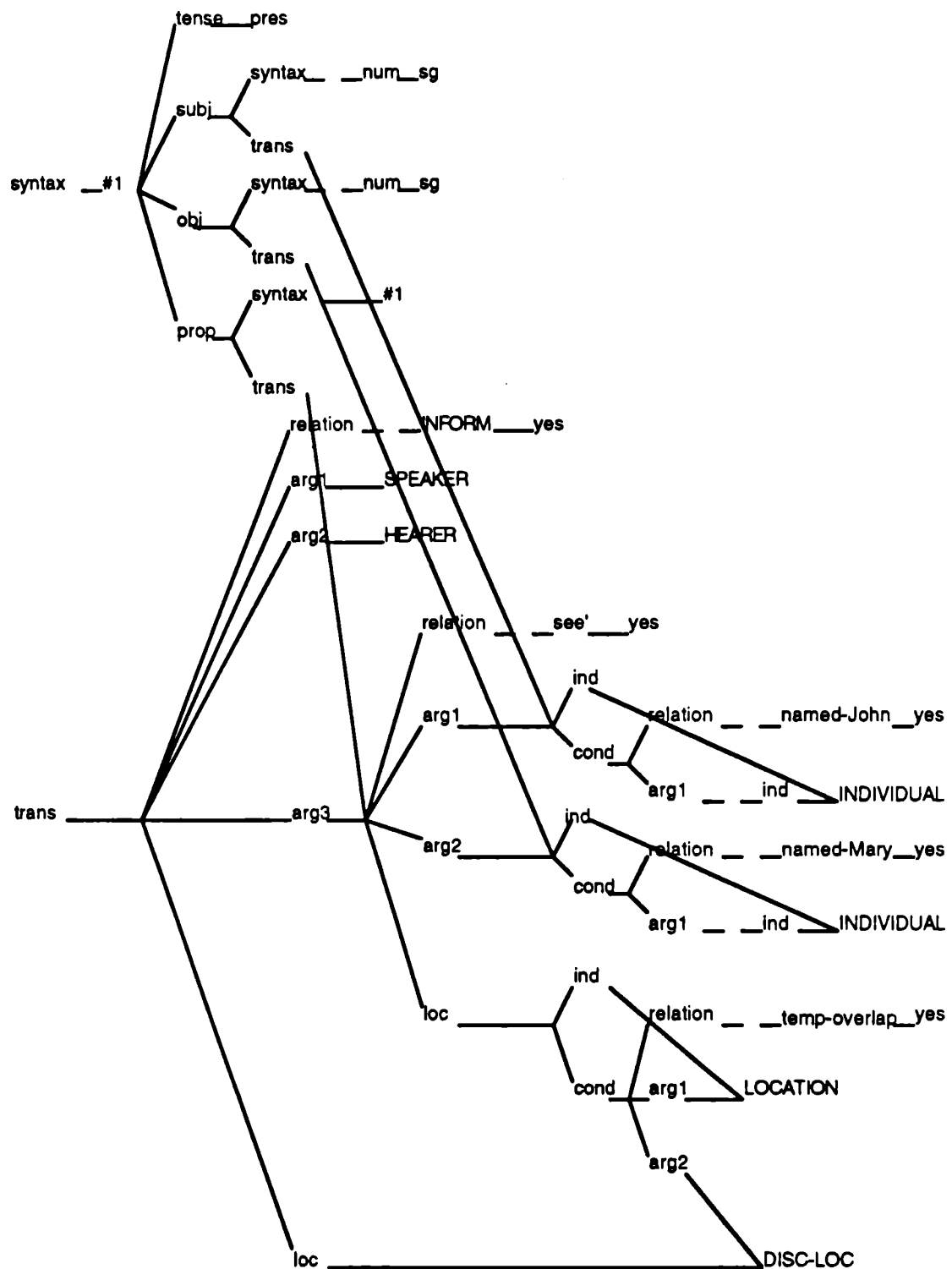


Fig. 4 Feature structure with interrelated syntax and trans substructures

6. Modes 1 and 2: Shortcuts by exploiting similarity

This, then, was the most elaborate mode. Now let us consider the modes that allow the system to exploit structural similarities between the languages – modes 1 and 2 in fig. 1. The idea is that the system itself should be able to decide that *this* chunk corresponds to a target construction word-by-word, and hence is to be tackled in Mode 1, whereas *this* chunk corresponds in a slightly more indirect fashion, with discrepancies in constituent order and grammatical formatives, and hence Mode 2 is in order, while, finally, *this* one does not correspond in any interesting way at all, so here we have to resort to Mode 3 and retrieve a situation schema. The basis for making such decisions will have to be language pair specific information. At the outset, however, the language descriptions are independent of any specific translation partner. The languages are described in their own terms – except for the obvious fact that the same grammatical apparatus has been employed, ensuring that the same type of grammatical phenomenon is described in the same terms in every language. But on the basis of such descriptions grammar comparisons can be performed automatically. An algorithm has been implemented which to some extent pre-compiles grammar pairs: it compares the entities in the two grammars and the two lexicons and adds information about the results of the comparison to them. Thus after the comparison the language descriptions will contain information about their partners. Let us briefly consider how this will be utilized in Mode 1 and Mode 2.

Mode 1 is the default mode from which the system departs only when triggered to do so. It is the mode of word-by-word correspondence. Even so, some syntactic analysis has to be performed, in order to achieve disambiguation of homonymous forms, and in order to detect cases where Mode 1 is insufficient. Therefore a syntactic tree is derived. The rules and lexical entries utilized in this derivation will contain information to the effect that an identical tree with the same compositional properties can be derived by the target language rules and lexical entries. This means that we do not need to do that: when the correspondence between source and target string is that close, we can forget about the target grammar; the source tree itself can be used. Then the source lexical entries at the terminal nodes are replaced by corresponding target entries, whereupon the resulting structure enters stage 3 of the synthesis procedure (cf. fig. 1) during which compatible target word forms are found. This procedure will appropriately handle gender clashes and various kinds of one-to-many correspondences between the two lexicons. Mode 2 is in order in cases where source and target string still correspond with respect to the sets of sense-carrying words they contain, but differ in constituent order, in the presence of sense-less grammatical formatives, or both. In this case the source tree cannot be used, but the source feature structure, including its grammatical information (its f-structure in LFG terms) is still useful. An example of such a correspondence would be Norwegian “den nye bilen min” vs. Swedish “min nya bil” ‘my new car’. The grammar comparison has identified cases where a rule in one language corresponds to a rule in the other with respect to sense-carrying daughters and compositional properties, but not with respect to constituent order or sense-less daughters. In such cases pointers have been constructed between the rules. Hence the procedure is that the system recognizes the pointer, retrieves the target rule, overwrites its feature structure over the source feature structure, and starts top-down prediction of target rules constrained by the modified source feature structure. In other words, it enters stage 2 of the full synthesis procedure.

Finally, Mode 3 is triggered when the parse reveals either a rule or a lexical entry with no Mode 1 or Mode 2 correspondent in the target language.

This was a very brief sketch of a system which operates partly on interlingua principles – in Mode 3 – and partly on transfer principles – in Modes 1 and 2. I have suggested that a semantic representation ideally should be able to capture everything in terms of which we define translational equivalence (at least to the extent that such equivalence is reducible to pre-established correspon-

dences between elements in the language descriptions), and that such a semantic representation can be seen as a kind of theoretical interlingua expression. How does this work out in the case of the kind of equivalence relations that are captured in Modes 1 and 2? In Mode 1 we utilize common tree structures in the two languages, in Mode 2 we utilize common syntactic feature structures. In other words, in these modes we have equivalence with respect to *types of linguistic signs*: the same linguistic devices are employed. As we have seen, this is one kind of equivalence we want to capture, since it is involved in achieving connotative and formal equivalence. But if translational equivalence may involve such grammatical equivalence, and semantics is to characterize all aspects of translational equivalence, then semantics has to be able to refer to aspects of grammatical form. Is this reasonable?

7. Language as Part of the World

Several situation semanticists (Robin Cooper, Stanley Peters, Jean Mark Gawron) have been working towards the development of a situation theoretic account of grammar itself. The problems addressed by Cooper do not pertain to translation, but rather to the situation theoretic characterization of the information states attainable by human and artificial information processors. A grammar, according to his analysis, is a relation between possible linguistic utterances and possible types of facts in the world around us. This is no place to go into details; suffice it to say that this approach involves treating linguistic entities – words, sentence constructions, grammatical categories etc. – as “things in the world” along with other things that human beings can talk about and relate to. This is a desirable perspective; semantics ought to be able to account for language as something which occurs in the same world as the one language relates to, and not as something occurring in a domain entirely of its own. This is obviously necessary in order to account semantically for reflexive language use, that is, use of language to talk about language, in expressions like “the word ‘horse’”, “the expression you just used”, “that was a bad sentence”, etc. Another example is the usual situation semantic analysis of *names* (fig. 5).

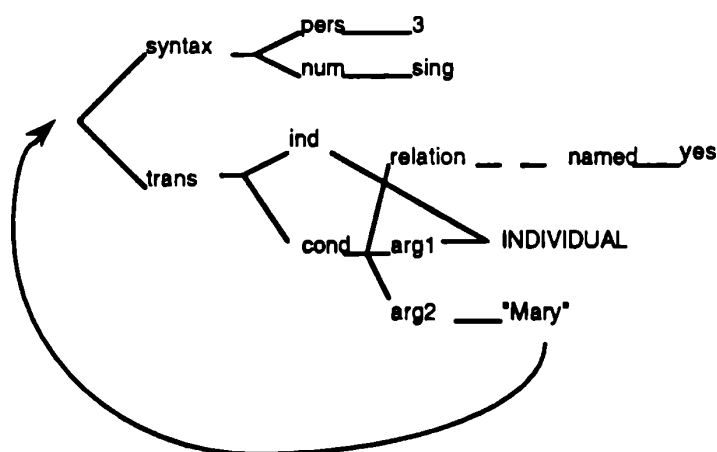


Fig. 5 Circular representation of a name

The analysis specifies that a precondition for using the name to refer to an individual is that the individual enters into the relation *named* with the name itself. In other words, the name enters into the specification of its own semantics, as part of the type of described situation it relates to. There is an element of circularity in this. If we interpret the feature structure as a representation of the name itself, the result is that the feature structure will contain a circular path.

In this case the linguistic entity itself occurs in its described situation, which is slightly special. But the occurrence of linguistic entities in *discourse situations* is quite typical, of course, and discourse situations are also part of what enters into the specification of linguistic meaning in a situation theoretic framework. Hence the element of circularity could become quite widespread if we develop the situation theoretic account in some detail: linguistic signs become essentially circular structures, containing themselves as constituents of their "semantic" subparts. This is a consequence of understanding the meaning of an expression as the way it constrains the relation between discourse situations in which it can be used and objects it can describe. Intuitively, the circular structure expresses the fact that an essential property of any discourse situation in which sign S is used, is that S is a constituent in it.

A consequence of this is that if we assume that translational equivalence is to mean equivalent situation schemata, then a sign will only be translationally equivalent with itself. This captures in a fairly brutal way the unique, non-translatable character of linguistic signs: the insight of many translators that the perfect translational equivalence relation across languages is empty. What we do in practice is search for target expressions that are equivalent with respect to *subsets* of the information in the schemata. In fact, I believe that we do want a theory of translation that accounts for its basic impossibility, while at the same time allowing for various approximations to the unattainable ideal.

Considerations like these might be a starting point for developing a semantic theory of translation – a study of the semantics *of* translation rather than simply working with semantics *for* translation. As I have stressed, the theoretical constructs of such a theory are not necessarily to be taken as models for direct implementation, but they might still provide the work with some theoretical basis.

8. References

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