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## A Frame for FRAMES

## (A Few Remarks on the Methodology of Semantically Guided Text Processing)

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1. The differences in the various linguistic paradigms have in the main been caused by different approaches to semantics. Lewis or Montague do not accept the semantic component of Chomsky's theory as 'semantics', because Chomsky does not operate with truth values. Montague's highly complex grammar does work with truth values, but still it is justifiedly applied to Montague Grammar what Lakoff said about formal descriptions in general: "What is wrong with formal descriptions is that they only allow for those facts that happen to be able to be dealt with by the given formalism" (Lakoff 1974: 153). Generative semanticists apply this statement also to Chomsky's theory and try to develop a flexible 'natural logic', which, they claim, is better suited to describe aspects of meaning than formal theories. In my opinion, however, the disadvantage of generative semantics is that the status of this modified paradigm is not at all clear. But at least the generative semanticists try to develop a theory, which cannot be said of most of the work presently done in artificial intelligence, where the desirability of constructing a theory is explicitly denied, since all they do, they say, is nothing else but 'engineering', simulating and testing of 'understanding natural languages' in simple situations (cf. Schank and Nash-Webber).

In recent studies on semantics such terms as 'logic'/'natural logic', 'inference'/'implicature', 'comprehension', 'understanding', 'context' etc. are used frequently. This seems to support Fillmore's statement that "issues in semantics that have no conceivable application to the process of comprehension cannot be very important for semantic theory" (Fillmore 1974).

One of the basic questions in connection with the investigation of comprehension concerns the rôle which "linguistic information about the meanings of words or sentences and factual information about things and events" (Fillmore 1974) play in comprehension. In trying to set up a theory of comprehension this question can be reformulated as follows: (a) What kind of meaning-postulates are required for the semantic interpretation, and (b) how should the lexicon component of the theory be constructed and how flexible should the interaction be between theory and lexicon? In 'engineering' terms this means, how much commonsense knowledge must be stored in the memory of a computer to allow the simulation of a given situation appropriately?

Logico-semantics-like formal linguistic theories operate

with "possible (and rather restricted) worlds", artificial intelligence research produces interesting ideas in connection with 'scenes and frames', where it is stressed that it is necessary to analyze how the different kinds of frames can/should be constructed (cf. Charniak 1975).

Whatever one may think about the necessity of constructing formal theories, one cannot deny the validity of the following two points:

- (a) It is necessary to have a theoretical framework to integrate the results of research on various fragments. In this context it is appropriate to quote Bar-Hillel who asks "what good does it do to deal with torsos of fragments of natural language if we do not even see how to expand the treatment of those fragments to enlarge pieces? My positive claim is, if you do not see how to extend your treatment, do not give me a treatment of any fragment" (Bar-Hillel in Heidrich 1974: 347). From other similar comments I should also like to mention Woods (1975: 148).
- (b) It is necessary to develop a (formal or at least disambiguating) theoretical language. In connection with artificial intelligence research Woods complains that "one of the depressing methodological problems that currently faces the field of artificial intelligence and computational linguistics is a general tendency to use terms imprecisely and for many people to use the same term for different things and different terms for the same things" (Woods 1975: 149). This does not only apply to computational linguistics but, unfortunately, to other branches of linguistics as well.

It is the aim of this paper to present some aspects of a theoretical framework which (a) should enable the flexible description of all relevant aspects of meaning and text comprehension (in such a form that it guarantees the integration of results of research done in various types of semantics so far, and also, if possible, of the methods used), and (b) operates with a theoretical language easily used to construct representations of natural language texts. This theoretical framework is the so-called "text structure - world structure theory" (with the German abbreviation TeSWeST).

The term 'frame' in the title refers to this theoretical framework, the term 'FRAME' is used as in artificial intelligence: there a FRAME is the representation of commonsense knowledge necessary to understand a standard situation (e.g. shopping at the supermarket).

2. the TeSWeST aims at describing the syntactic, semantic and pragmatic structure of natural language texts. In detail this means

- (a) the assigning of (all possible) syntactic (intensional-semantic) representations to natural language texts,
- (b) the world-semantic (extensional-semantic) interpretation of the individual intensional-semantic representations,
- (c) the generating of syntactic (intensional-semantic) representations, and
- (d) the comparing of a text, of the intensional-semantic representation of a text, and of the extensional-semantic representation of a text with other texts, the intensional-semantic representations of other texts, and the extensional-semantic representation of other texts, respectively.

Since these points represent a generalization of what logical semantics has aimed at, the structure of the TeSWeST must necessarily be analogous to logic. This not only applies to the structure of the theory's components, but also to the relation between the different components. There are two reasons why I speak of analogy rather than identity with logic:

- (a) The aims of the TeSWeST are much more general than the aims of logical semantics, and
- (b) the range of objects to be described by the TeSWeST (i.e. natural language texts) is much larger than the range of natural language objects described by logico-semantic theories so far.

Given this difference between logical semantics and the TeSWeST, then it follows from this that the traditional structure of a logical theory, i.e. logical syntax plus logical semantics, must be replaced by a much more complex structure in the TeSWeST, at least at the present stage of research. This complex structure is shown in Figure 1 (where the direction of the analysis is indicated).

The main components of the TeSWeST are

the Text Grammatical Component (TGrC),  
the World-Semantic Component (WSeC), and  
the Lexicon Component.

The dominating component is the WSeC. It directly or indirectly determined the structure and functions of the other components. It is the task of the WSeC to carry out the world-semantic (extensional-semantic) interpretations (the result of which is a world-semantic representation (WSeR)) and to draw world-specific logico-semantic inferences (LoSemInf). So far, in logico-semantics only interpretations of relatively restricted natural language fragments have been carried out, one can therefore only hypothesize about the structure of a complex logic (Logico-Semantic Interpretation Component (LoSemIC)) capable of interpreting any kind of natural language texts.

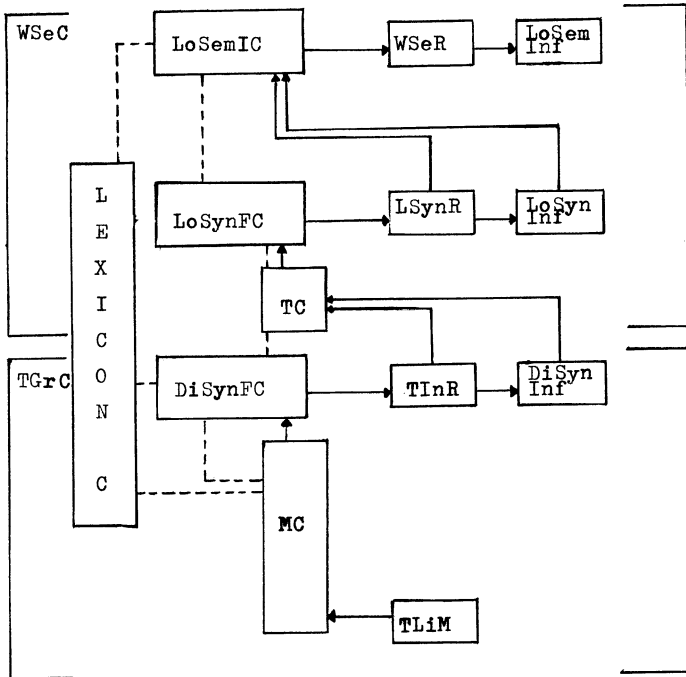


Figure 1

## Explanation of abbreviations used:

|          |  |
|----------|--|
| DiSynFC  | Disambiguating Syntactic Formation Component |
| DiSynInf | Disambiguated syntactic inferences           |
| LoSemIC  | Logico-Semantic Interpretation Component     |
| LoSemInf | Logico-semantic inferences                   |
| LoSynFC  | Logico-Syntactic Formation Component         |
| LoSynInf | Logico-syntactic inferences                  |
| LoSynR   | Logico-syntactic representations             |
| MC       | Mapping Component                            |
| TC       | Translation Component                        |
| TGrC     | Text Grammatical Component                   |
| TInR     | Intensional-semantic text representations    |
| TLiM     | Linear text manifestations                   |
| WSeC     | World-Semantic Component                     |
| WSeR     | World-semantic representations               |

Because of this hypothetical nature of the LoSemIC the structure of the Logico-Syntactic Formation Component (LoSynFC) must remain hypothetical also. It is the task of this component to construct syntactically well-formed formulae (logico-syntactic representations (LoSynR)) and to define logico-syntactic inferences (LoSynInf).

The hypothetical nature of the WSeC also affects the structure of the TGrC. On the one hand it must contain a Disambiguating Syntactic Formation Component (DiSynFC) to enable the construction of unambiguous (intensional-semantic) text representations (TInR) based on the analysis or generation of natural language texts, the TInR-s should be translatable into a logico-syntactic language. On the other hand it must contain a Mapping Component (MC) which maps the TInR-s to natural language texts (linear text manifestations (TLiM)) or the TLiM-s to all admissible TInR-s. Apart from the formation rules of the TInR-s the DiSynFC also contains rules for drawing disambiguated syntactic inferences (DiSynInf). (A Translation Component (TC) must guarantee the transition from DiSynFC to the LoSynFC.)

The Lexicon contains syntactic and semantic information and is closely connected with both the TGrC and the WSeC. ('Semantic information' here refers to the lexical and encyclopedic information average native speakers/listeners of a given language have access to when they draw their inferences from natural language sentences/texts in standard contexts, and a register of proper names, which contains all admissible proper names with their minimal classification characteristics.)

3. It is the task of the DiSynFC to guarantee the well-formedness of the TInR-s. Since lack of space does not allow me to present the rule system of the DiSynFC, I want to demonstrate some of the aspects of this system by discussing one representation. A complete well-formed elementary unit of a TInR is an 'atomic text'. The atomic text given in (2) can be assigned as a possible TInR to the meaning of utterance (1):

(1) I think Anne left for London yesterday.

(2)  $T_1 = [\text{CASE-BE}] \{st:t_1, sl:l_1, up:p_1^P\}$   
 $P_1^P = [\text{TELL}] \{ap:\text{Pers1}/=\underline{A}/, leave:\text{Pers2}/=\underline{B}/, eo:p_1^W\}$   
 $P_1^W = [\text{CASE-BE}] \{st:t_2, sl:l_2, up:p_1^W\}$   
 $p_1^W = [\text{THINK}] \{se:\text{Pers1}/=\underline{A}/, eo:p_1\}$   
 $P_1 = [\text{CASE-BE}] \{st:t_3, sl:l_3, up:p\}$   
 $p_1 = [\text{LEAVE}] \{ap:I01, ls:I02, lg:I03\}$   
 $\wedge[I01 = \text{Anne} /< \text{Uw1}, \text{Uw2}, \text{Uw3}, \text{Uw4}]$   
 $\wedge I02 = \text{Q1}^{\sim}\text{CU}\{x|[\text{PLACE}]\{up:x\}\}/< \text{Uw1}, \text{Uw2}, \text{Vw3}, \text{Vw4}\}$   
 $\wedge I03 = \text{London} /< \text{Uw1}, \text{Uw2}, \text{Uw3}, \text{Uw4}\}]$

$\wedge [t_N = t_1 > t_2 > t_3$   
 $t_3 \in T_3, [\text{DAY}] \{ \text{up}: T_3 \};$   
 $t_1 \in T_1, [\text{DAY}] \{ \text{up}: T_1 \}; T_1 \succ T_3 ]$   
 $w_1 = \text{the real world of } \underline{A}$   
 $w_2 = \{ P | [\text{THINK}] \{ \text{se}: \underline{A}, \text{eo}: P \} \}$   
 $w_3 = \text{the real world of } \underline{B}$   
 $w_4 = \{ P | [\text{TELL}] \{ \text{ap}: \underline{A}, \text{go}: \underline{B}, \text{eo}: [\text{THINK}] \{ \text{se}: \underline{A}, \text{eo}: P \} \} \}$

**Commentary:**

- (a) In order to mark the actual utterance status of (1), it is necessary to supply information about the communication situation "A communicates to B that (1)". In accordance with this information (2) also has to be completed to make (2) the representation of (1) as an utterance. But I do not want to deal with this problem here; in (2) A and B refer to the 'communicating persons',
- (b) units in capital letters are no real words of the given natural language but constructs in the Lexicon assigned to the respective words,
- (c) "p" indicates a propositional-(function-)frame, while "p" indicates a predicate-(function-)frame; we speak of a 'function' if an argument-place of the frame in question has not yet been filled by a constant. "P" indicates the 'performative modal' character and "W" the 'world-constitutive' character of the respective unit, the figures as subscripts indicate the hierarchical unit (atomic text) the units belong to,
- (d) "st", "sl", "up", "ap", "go", "eo", "ls", "lg" are so-called 'argument labels'. They indicate the function of individual arguments in the given predicate-frame. In the sequence as above they stand for specification temporal, specification local, unspecified participant, agent participant, goal object, effected object, local source, and local goal (cf. Heydrich 1976),
- (e)  $I_{01}$ ,  $I_{02}$ ,  $I_{03}$  are 'reference indices';  $I_{02}$  is a so-called 'individual description' which has to be read as follows: 1 (=Q1) counting unit (= CU) of those "x"-s which are "places" ( $\{ x | [\text{PLACE}] \{ \text{up}: x \} \}$ );  $W_{w1}$  indicates uniqueness, unambiguous referentializability,  $V_{w1}$  indicates variability in the world  $w_1$ ; all reference indices have to be specified for U or V in all the worlds in which they occur,
- (f) the  $w_i$ -s are world-indices; " $w_2$ " refers to the world (= system of propositions representing events or states) constituted by A's thinking; " $w_4$ " refers to the world constituted by A's thinking and presented by A to B; the symbols "A" and "B" mark the persons, whose world/sub-world is  $w_2$  and  $w_4$  respectively,
- (g) " $t_N$ " is the net of temporal relations; " $\underline{x} > \underline{y}$ " has to be read as follows:  $\underline{x}$  is (chronologically) later than  $\underline{y}$ ;



"T1 > T3" means that T1 occurs one chronological unit later than T3.

The functors of the predicate frames can be enlarged by operators or operators modified by operators. Thus the following frames can be produced:

- (3) [[[VERY] SLOW] WRITE]{ap:I01}
- (4) [[[VERY] SLOW] GIRL]{up:I01}

By means of connective-function-frames the atomic texts can be connected to form complex texts. In most cases a complex text manifests/constitutes a world-complex. Due to the fact that the  $p^P$  and the  $p^W$  frames are integral parts of well-formed atomic texts, the rule system of the DiSynFC contains the appropriate means for the representation of this world-complex. The rule system of the DiSynFC also allows to draw 'syntactic inferences', e.g. from (3) the syntactic inferences [[[SLOW] WRITE]{ap:I01} and [WRITE]{ap:I01} can be drawn.

For the sake of terminological clarity I will further specify the term 'frame' in the following way: The TeSWeST as a theoretical framework is called a T-frame. The predicate-function-frames (e.g. [WRITE]{ap:x, eo:y}), the connective-function-frames (e.g. [IMPLIES]{is:P1, im:P1}), ("is" = implicans, "im" = implicatum); and the operator + operand-function-frames (e.g. [[SLOW]...] or [[VERY]---]) are simple frames in the Lexicon, they are called sL-frames. The representation in (2) is a special frame, a grammatical (intensional-semantic) representation, it is called a G-frame.

4. The basic component of the TeSWeST is the Lexicon. The lexicon entries enable on the one hand the combinatorics of the DiSynFC, and on the other hand the construction of synonymous expressions and the explicit reconstruction of those inferences ('implicatures') which can be drawn on the basis of common-sense knowledge.

The argument/operand slots of the sL-frames are marked in such a way that they can only be filled by units fulfilling the required classification characteristics, that way the combination of lexicon entries is controlled. In order to handle the representation of synonymous structures and implicatures economically and consistently on all levels (word level, sentence level, and text level), the Lexicon must be constructed along the following principles:

- (a) a part of the sL-frames is to be regarded as 'primitives'; the primitive sL-frames must fulfil the following requirements
  - (i) with the help of the primitives all non-primitive sL-frames must be definable up to a required depth of common-sense knowledge;

- (ii) the primitives should have at least a restrictedly universal character ('restricted universality' here means 'universality in a certain group/class/set of languages');
- (b) the non-primitive sL-frames can be defined in several steps, i.e. definition-chains lead from the definienda to those definitientia which contain only primitive sL-frames;
- (c) the definitions are constructed like (atomic or complex) texts.

If one follows these principles, then

- (a) the Lexicon is free of circular definitions (or circularity occurs only within the set of primitive sL-frames),
- (b) the TGr and the Lexicon are structurally coordinated: the Lexicon is the Lexicon of the TGr, the TGr is the grammar of the Lexicon.

There is a clear analogy between the definitions in the Lexicon (subsequently 'L-definitions') and a part of the FRAMES (as used by Charniak) as far as their content is concerned. The definitientia in the Lexicon constitute complex L-frames (cL-frame); as to the content they are FRAMES. But definitientia and FRAMES are different with respect to their structure. L-definitions (and the DiSynFC) are constructed in a way to allow the combination not only of definienda but also of definitientia, i.e. G-frames can be generated from sL-frames and/or cL-frames. This means that complex FRAMES can be constructed from elementary FRAMES systematically. For example, the FRAME "Shopping at the supermarket" can be constructed as follows. We assume that

[DO]{ap:io1, eo<sub>f</sub>:SHOPPING-of-io1}, [SUPERMARKET]{up:io2},  
[BASKET]{up:io3}, [CART]{up:io4}

are sL-frames to be defined ("eo<sub>f</sub>" indicates that the argument 'eo' (= SHOPPING-of-io1) is an inseparable complement of the functor (= DO); "io1", "io2", ... are reference indices used in the Lexicon). The structure of the L-definitions are approximately as follows (the definitions here are only given as illustrations, they are not well-formed G-frames):

- (5) [DO]{ap:io1, eo<sub>f</sub>:SHOPPING-of-io1} =<sub>D</sub>
  - (i) io1 wants to possess the set of objects consisting of the elements m1, ... mk;
  - (ii) io1 goes to place L/places L1, ... Li, where these objects can be bought;
  - (iii) io1 chooses the objects m1, ... mk at the given place(s) in the usual way and becomes the owner of these objects by paying with tokens accepted in the given place(s);
- (6) [SUPERMARKET]{up:io2} =<sub>D</sub>

io2 is a large self-service store where persons

do their shopping with a basket<sub>i</sub> or a cart<sub>j</sub>  
 (the indices "i" and "j" refer to the special  
 character of the objects in question);

(7)  $[BASKET_i]\{up:io3\} =_D$

a container used for shopping at a super-  
 market; ...; used in a way that ...;

(8)  $[CART_j]\{up:io4\} =_D$

a vehicle used for shopping at a supermarket;  
 ...; used in a way that ...;

The G-frame ("somebody (= io1) does his/her shopping at the supermarket") of the complex FRAME "Shopping at the supermarket" can be generated as follows: first the G-frame (9) is constructed with the appropriate definienda sl-frames, then the substitution by the definientia and the so-called canonical transformations, which guarantee well-formedness, must be carried out:

(9)  $P_2 = [CASE-BE]\{st:t, sl:io2, up:p2\}$

$p2 = [DO]\{ap:io1, eo_f:SHOPPING-of-io1\}$

$\wedge [SUPERMARKET]\{up:io2\}$

When substituting  $[SUPERMARKET]$  by the definiens of (6), either basket<sub>i</sub> or cart<sub>j</sub> must be selected and, accordingly, either the definiens of (7) or the definiens of (8) must be inserted in the definiens of (6).  $[DO]\{ap:io1, eo_f:SHOPPING-of-io1\}$  has to<sup>be</sup> replaced by the definiens of (5). The canonical transformation consists in the replacement of the part (iii) of the definiens of (5) by the appropriate part of (7) or (8) (cf. "used in a way that ..."). The transformation is directed by the fact that the place L of (5)(ii) is allotted the "io2" of (9).

I hope that even this short presentation succeeded in giving an idea about the Lexicon-conception of the TeSWeSt. The main point is the homogeneity of the Lexicon and the TGr (and not the homogeneity of the FRAMES and a programming language).

5. As to the WSeC I only want to add two remarks here:

- (a) The world-semantic (extensional-semantic) interpretation requires that the TInR-s are translatable into LoSynR-s. This seems to be practicable, the 'case-grammatical' basis of the DiSynFC is no obstacle to the translatability into e.g. a predicate-logic-type of language.
- (b) When constructing semantic interpretations it is a fundamental question how to use the Lexicon flexibly. The definientia represent the uses of lexical units in 'standard contexts' (intensions relating to standard extensional contexts) and thus they are directly inter-

pretable only with respect to such contexts. The DiSynFC should be flexible enough to allow semantic interpretation with respect to all types of contexts.

Finally, I want to emphasize that the TeSWeST is a theoretical framework in the very sense of the word, a framework, the aim of which is to develop an integrated semiotic theory of natural languages. Until now it functioned as a 'progressive problem shift'. (For further information about the TeSWeST and the structure of its Lexicon see the bibliography.)

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