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Semantic Macro-Structures and Knowledge Frames in Discourse Comprehension

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INTRODUCTION

This paper outlines a theory of macro-structures within a larger framework of a model of cognitive information processing. We will focus on semantic structures and processes of discourse comprehension; in particular, we will formulate the macro-rules underlying the global interpretation of discourse. Although the focus is on discourse comprehension, the basic principles of macro-processing also are valid for other cognitive domains, such as vision, action, thinking, and problem solving.

The notion of macro-structure is introduced as a partial explication of such notions as 'schema' or 'plan' as they are currently used in cognitive psychology and artificial intelligence. Semantic macro-structures will be distinguished from other kinds of 'schematic' structures of discourse, such as narrative super-structures. Finally, we will elucidate the relationship between macro-structures and frames.

In linguistics, macro-structures have been postulated in order to account for the 'global meaning' of discourse such as it is intuitively assigned in terms of the 'topic' or 'theme' of a discourse or conversation. The assumption is that these notions cannot be accounted for in terms of current logical, linguistic, and cognitive semantics for isolated sentences or sequences of sentences. In disciplines such as rhetorics and narrative theory, macro-structures may constitute the semantic basis for specific categories and rules. For instance, the setting of a narrative should be defined at a macro-level of analysis and cannot be defined in terms of individual sentences (or their underlying propositions). Similarly, well-known categories such as 'premise' and 'conclusion' in an argument also operate

on global structures of discourse. Besides defining the global coherence of discourse, macro-structures also contribute to 'local' coherence at the micro-level of connections between propositions in composite sentences and successive sentences.

In this paper, we will show that some fundamental problems of cognitive psychology can be accounted for in terms of macro-processing of complex semantic information. If a discourse is at all long, subjects are unable to process it at a micro-level alone: not only are they unable to store and retrieve such discourse verbatim, but they are also unable to retrieve the constituent propositions. At the same time, if the sequences of sentences can be assigned a macro-structure, they will be recalled much better than scrambled sequences. Thus, comprehension (as well as production) probably takes place at several levels, such that lower-level information is organized, reduced, and represented at higher levels. These processes involve the use of macro-rules; the input to the macro-rules is the micro-structure, and the output is the macro-structure. Macro-structures help to explain the ability to summarize discourse, and in general to use information from discourse for other cognitive tasks, even if the individual propositions of the discourse are no longer accessible. Similarly, macro-structures may provide further insight into the structure and use of frame-like representations of conventional knowledge in discourse comprehension and other cognitive tasks.

SEMANTIC STRUCTURES OF DISCOURSE

We will deal primarily with *semantic* macro-structures, although other kinds of global structures (e.g., narrative and pragmatic ones) may also play a role in the global organization and comprehension of discourse. One possible way to make semantic structures explicit is to use a formal language, such that expressions of this language can be given a suitable interpretation in the formal semantics of that logical language.¹ This formal semantics may be of the usual model-theoretical sort, (e.g., involving notions such as possible worlds). One of the difficulties with other kinds of representations (e.g., graphs) is that they do not yet have an associated formal semantics (cf. Woods, 1975).

Micro-structures and Coherence

Micro-structures, the sequence of propositions underlying the sequence of sentences of the discourse, constitute the input to the macro-rules. The micro-structures themselves require some preliminary semantic description. We will

¹ For an introduction to formal semantics (especially of modal logics), see Hughes and Cresswell (1968); for application in natural language, see Cresswell (1973). A brief survey is given in van Dijk (1977). See also Keenan (1975).

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introduce the abstract concept of a *text* to refer to the abstract structure of a discourse. We can characterize the structures of texts at different levels of description.² At one level of description, a text is simply an ordered sequence of propositions, which under various pragmatic, stylistic, and other constraints is mapped onto a sequence of sentences.

Propositions are construed in the usual way, namely, as n-place predicates followed by n arguments which may be bound by quantifiers. Propositions may be modalized by various kinds of operators (tense, knowledge, belief, obligation, etc.), and connectives may be used to make compound propositions. The semantics of the formal language representing propositions provides recursive truth (or satisfaction) conditions in a constructive way. That is, interpretations of larger units depend on the interpretation of smaller units. Predicates are interpreted as properties or relations and arguments as individuals. Modal operators are interpreted in terms of possible worlds; for example, *It is necessary that p* is true in a world w_i iff *p* is true in all possible worlds which are accessible from w_i . Sentences have as their referents the facts in possible worlds. Thus, the sentence *Peter is ill* refers to the fact that Peter is ill now, i.e., in the actual possible world at the moment of the utterance. However, unlike classical formal languages, natural language is intensional. That is, we want to assign not only extensional referents, but also meanings. In particular, the extensions of an expression are assigned on the basis of its intensional meaning. Such intensions are functions, taking possible worlds as arguments and extensions as values. Thus, the phrase *the book* has an intensional meaning, namely the individual concept of a book, which may take various extensions, i.e., actual books referred to, in particular situations. Both intensional and extensional interpretations are necessary in an account of the semantic structures of discourse.

A semantics of discourse is characterized by relative interpretations: sentences in a discourse sequence are not interpreted in an 'absolute' way, but relative to the interpretation of other, mostly previous, sentences of the discourse. Sequences satisfying the constraints of relative interpretation are called *linearly coherent*. One major coherence constraint is connection. Two propositions are considered to be pairwise connected if the facts they denote are related. This relation can be made explicit in terms of possible, probable, or necessary conditions, components, or consequences. Connections between propositions are typically expressed by natural connectives such as *and*, *because*, *yet*, *so*, etc. (cf. van Dijk, 1977).

Sequences of propositions exhibit other coherence properties besides pairwise connections. For example, two expressions may both refer to the same facts, properties, or individuals. It should be noted, however, that in general these

²For introduction and further reference about the linguistic study of discourse, see Halliday and Hasan (1976), Petöfi and Rieser (1973), van Dijk (1972, 1977), and van Dijk and Petöfi (1977). The present introductory remarks about text structure are complemented by van Dijk (1977).

conditions are neither necessary nor sufficient for coherence. Discourse coherence is not primarily a matter of meaning, but of reference. Roughly speaking, the coherence of the discourse depends on the coherence of the possible-world fragment or course of events it represents. One of the conditions that makes a text uninterpretable is the impossibility of imagining situations where it could be satisfied. Of course, numerous formal and empirical details are omitted in this presentation. A further note of caution is that our theoretical abstractions and generalizations apply to an idealized discourse. Actual discourses that are produced, understood, and accepted do not always have a fully correct textual structure. Additional rules of pragmatics, cognitive strategies, and social conventions must account for the relevant conditions of acceptability of non-ideal discourses.

There is another constraint on linear coherence that is not referential, but rather intensional or conceptual; not only must denoted facts be related, but this relation must be relative to a *topic of discourse*. That is, the facts must originate in the same range of semantic space. Thus, John's playing the piano may, as such, be independent from Mary's knitting, but both actions lie in the same range, namely, human leisure activities. Thus, connection conditions can be established relative to other propositions, which may or may not be explicitly stated in the text. For example, a sequence may be coherent because each fact relates to the general theme. The notion of a theme or topic of a discourse or a conversation will be reconsidered in terms of macro-structures. This means that conditions for linear coherence may depend on conditions for global coherence.

Coherence is not only semantic, but may also be determined by pragmatic conditions. Clearly, connections between facts should be satisfied not only 'objectively', but also relative to language users and communicative contexts. Similarly, the connections must relate not only facts but also speech acts. Thus, one speech act may constitute a condition, component, or consequence of another speech act. The details of these various pragmatic conditions on coherence will be ignored here, as well as other principles of cooperative communication and interaction (cf. van Dijk, 1977).

A major pragmatic constraint on discourse is that it be informative; consequently, information that the hearer already knows need not be expressed and asserted. This knowledge may be contextual or general. Contextual knowledge pertains to properties of the communicative situation, such as the presence of certain objects. This allows for coherence based on the context, such as the use of indexical pronouns (*I, you, this, that, yesterday, now*, etc.). General knowledge includes lexical/semantic information pertaining to the meaning postulates of the language — for example, knowing that the word "bachelor" entails unmarriedness. Alternatively, the general knowledge may be conventional, involving shared knowledge about the 'world' (e.g., knowing that Mexico is warm). Conventional knowledge contains not only actual facts, but also 'possible facts' compatible with the actual world. The latter kind of conventional knowledge can be thought of as frames, which will be discussed in more detail later.

The propositions implied by the discourse need not be expressed. Some propositions may remain implicit, even though they are essential in the establishment of linear coherence in texts. For example, they may be 'presuppositions' of other propositions, or they may be necessary to allow the listener to draw certain inferences. If we call the sequence of propositions of a discourse the text base,³ we can distinguish between an implicit and an explicit text base. The explicit text base is the theoretical construct containing all the propositions necessary to give relative interpretations of each proposition of the sequence. The explicit text base may be mapped onto the implicit text base by deletion of known or inferrable propositions. It is the implicit text base which constitutes the input to the surface grammar. The distinction is not only important for cognitive reasons but also for grammatical reasons: the surface structure may contain 'traces' of the explicit propositions. One example of such a trace of the explicit text base is the use of pronouns without antecedents. Another is the use of definite articles without indefinitely introduced noun phrases. This is also the reason why an explicit text base may not be too rich and contain all implications of each proposition. Only those propositions are interpolated which are immediate conditions for the full interpretation of each expressed proposition.

Macro-structures

Beyond the linear semantic structure of discourse, we also postulate global levels of descriptions, namely macro-structures.⁴ Macro-structures are assumed to be semantic structures of discourse whose meaning and reference is defined in terms of their constituents' meanings. Just as the value of a sentence is a function of its predicates, arguments, and operators, similarly the meaning of macro-structures is a function of the meaning and reference of the constituent propositions of the explicit text base and the relations between those propositions. Since macro-structures are representations of meaning and reference at a more 'global' level of the discourse, they should satisfy the normal conditions of linear coherence as formulated above. That is, each macro-proposition must be interpreted with respect to other macro-propositions, including the implied propositions as defined above. Hence, macro-structures are explicit.

A macro-meaning is the unifying property of the respective meanings of a sequence of propositions of a discourse. This means that certain combinations of

³The notion of 'text base' has mainly been used by Petöfi and by Kintsch (1974) in cognitive psychology, where the experimental consequences of the distinction between implicit and explicit information are examined.

⁴The notion of macro-structure was first used by Bierwisch (1965) for specific (e.g., narrative) structures of discourse (and their specific cognitive consequences in processing). It has been elaborated, first in theoretical poetics, then in linguistics, in our earlier papers and books (see van Dijk, 1972, for reference), and finally taken up again within a cognitive perspective in Kintsch and van Dijk (1975), van Dijk (1975a), and van Dijk and Kintsch (1977).

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propositions may be assigned, as a whole, a meaning at another level. It is evident that states of affairs, events, or actions may be represented at different levels of description. For example, the fact that somebody is building a house may be represented simply by the proposition 'Peter is building a house.' At a lower level of description, the 'same fact' may be represented by a long sequence of propositions denoting the actions involved in house building, such as plastering and sawing. These actions are interrelated with respect to the global action of house building: they are executed under the scope of the same global intention or plan. Given our coherence conditions, these properties of possible worlds also determine properties of the discourse. That is, a combination of propositions denoting constituent actions of house building may be assigned the proposition 'Peter is building a house.'

Since there are several possible levels of description, a global description may constitute the basis of a still more global description. For example, at a still higher level of description, house building may be a condition, component, or consequence of a more global action or event, such as 'settling'. Hence, there is not one level of macro-structure, but several levels, as long as there are global concepts and facts defining the level. We will speak, however, of *the* macro-structure of a discourse to refer to the highest level of macro-structure for the discourse as a whole.

Characteristically, the relation of the macro-structure to the micro-structure involves notions such as importance or relevance: the macro-interpretation defines the most important or essential object or event denoted by a sequence of propositions. For example, at a certain level of description, it may be more important that Peter built a house than where he actually bought the bricks. This notion of importance may be made explicit in terms of conditions, constituents, and consequences at the macro-level: building a house, but not buying bricks from some particular dealer, may be a condition for another global action, such as living in the house or selling it.

If we substitute the macro-proposition for the sequence of propositions that it represents, we reduce the semantic information, in the sense of eliminating the details of the individual propositions. But the meaning or reference of a sequence as a whole is preserved. Indeed, we may say that the macro-structure is entailed by its micro-structure.

Macro-rules

Since macro-propositions need not be explicitly expressed in the text, we need some mapping rules to obtain the macro-structure from the micro-structure of the discourse, in other words, rules to transform one proposition sequence into another 'at another level' of description. This kind of semantic transformation we will call a macro-rule. The macro-rules must preserve global truth and meaning. Since macro-propositions need not be expressed in the discourse,

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during comprehension they must be inferred from the explicit text base. The macro-rules, then, must yield an abstract model of these processes of inference. The 'macro-interpretations' of the discourse consist of assignments of global meanings and references.

The properties of macro-structures that we discussed above determine some of the properties of the macro-rules. For example, since there are several levels of description of any event, macro-rules must be recursive: they can be applied to organize global meanings into still higher-level global meaning. From this recursive nature of the macro-rules it follows that the notion of macro-structure is relative to an underlying level of propositional representation, which in turn may be a macro-structure with respect to still more specific levels of representation.

A macro-structure is typically more general than its corresponding micro-structure. The first macro-rule, then, is GENERALIZATION. If somebody tells us he has a dog, a cat, and a parakeet, we may describe the same state of affairs with the more general statement that he has (three) pets. This rule operates not only on individual propositions but also on sequences of propositions, as in the three conjoined propositions of our example. GENERALIZATION holds for predicates in general, and hence applies both to nouns and verbs of the discourse. For instance, I may take the train to Paris and my friend may take a plane, but we are both going to Paris. In the example above, the kind of pet or the kind of transport become irrelevant at the macro-level, and can be replaced by the superordinate. Thus, the reductive nature of the macro-rule of GENERALIZATION is thus based on the deletion of certain essential properties which at some macro-level have become irrelevant, such that a whole set of discourse referents may be denoted by their common superset.

While macro-rules must abstract and generalize, there must be some restriction on the level of abstraction. We still want macro-rules to yield specific information and not too general (and hence, uninformative) concepts. So, the rule must select the immediate or smallest superconcept. This guarantees that 'dog' and 'cat' are not generalized recursively to 'animate beings' or 'concrete things'. Note that this is a formal rule. In actual linguistic and other cognitive behavior we may well reduce information simply by referring to the various toys of our children lying around, for example, as 'those things'. The general principle is that the least general superordinate is generated (if any exists). If there are several possible 'next' superordinates, or if abstraction is possible at various levels, there are constraints that determine the correct set of possibilities. These constraints are the topic of discourse and the pragmatic, cognitive, and social contexts. Thus, in the example above, 'pets' would be generated during a family discourse and 'mammals' would be generated in a biological discourse.

A second and closely related constraint is that there must be an upper bound on the application of macro-rules. Once a certain level of abstraction is attained, the rules should no longer be applied. The constraint we will use is rather simple: the application of macro-rules makes sense only if the reduced information is

propositional. Hence, the macro-rules will apply only on sequences of two or more propositions. It follows that each proposition which cannot be reduced by some macro-rule must itself become part of the macro-structure. This occurs in those cases where macro-propositions are expressed in the discourse itself. This non-application of a macro-rule will be taken as the application of a ZERO-rule, whose input and output are identical. Such a rule corresponds to a cognitive operation that determines that a piece of information of the expressed text-base must be relevant with respect to the discourse as a whole.

Let us now give a more precise definition of this first macro-rule:

(1) GENERALIZATION (M-I)

Given a sequence of propositions $E = (y_0(a_1), y_2(a_2), \dots, y_n(a_n))$, where $n \geq 2$, if there is a concept (I) such that each $a_i \supseteq I$, and if there is a concept A such that each $a_i \supseteq A$, then substitute (1) (A) for E, where \supseteq denotes immediate inclusion of the sets defined by the concepts.

The rule allows both the predicates and the arguments to be generalized by a super-concept. In such a case the nongeneralized concept may remain identical, e.g., $a_1 = a_2 = \dots = A$. It is also understood that if the arguments are identical the predicates should be different, and conversely. This is a pragmatic constraint of informativeness on natural language propositional sequences of discourse. Finally, it is required that we indeed do have a specific super-concept for the predicates or arguments of the propositions of the text base.

Since entailment is defined in terms of conceptual inclusion, we may reformulate the rule by stating simply that a sequence E of propositions may be substituted by a proposition P if P is entailed by each of the members of E. We see that the rule is based on an entailment relation, as was required above.

A special case of this rule is the generalization of complex predicates allowing a predicate such as 'to travel by train' to be replaced by 'to travel'. When the adverbial modifier is reconstructed as a separate atomic proposition, it can be deleted by the next macro-rule, to be discussed below. The same holds for other modifiers and complementa.

Some examples may clarify how this rule handles sequences of sentences. We will use the symbol \supseteq to denote the macro-operation involved.

- (2) (John was moving the chairs,
 John was moving the table, John was moving the furniture
 John was moving the chest . . .
- (3) (Father was cleaning the kitchen,
 Mother was typing her new book, The whole family was working
 The children were painting the doghouse)

In this last example we see that generalization is possible both of the subject terms and of the verbs.

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Whereas the GENERALIZATION rule abstracts from essential properties of objects or properties or relations, the next rule, DELETION, deletes full propositions from a given text base. It is difficult to formulate the precise conditions for the application of this rule. Its intuitive idea is that 'irrelevant' information may be deleted. The notion of 'relevance' or 'importance' of a proposition, relative to the discourse as a whole, will be made explicit in terms of interpretation conditions. We assume that each proposition expressed by a discourse should be considered as relatively unimportant if it is not a condition for the interpretation of another proposition.

Thus if we describe an episode in which Mary is playing with a blue ball and she breaks a window with the ball, the fact that the ball is blue is (normally) irrelevant; the proposition representing this fact may be deleted because it is not a condition for understanding the rest of the discourse. Similarly, a proposition is indirectly irrelevant if it determines the interpretation of a proposition which is itself deleted or substituted. However, these conditions for deletion are neither sufficient nor necessary. If the last proposition of a text base is not a condition for the interpretation of other propositions, it does not mean that this proposition is globally irrelevant. So we should add that a proposition should not be deleted if it denotes a consequence of an event denoted by a macro-proposition.

The deletion rule is essential for the reduction of information and operates in all those cases where the other rules do not apply. We may formulate the rule, provisionally, as follows:

(4) DELETION (M-II)

Given a sequence of propositions $E = (P_1, P_2, \dots, p_n)$, $n > 2$, then each proposition p_i may be deleted which is neither an interpretation condition for at least one proposition (mostly following p_i), nor a consequence of a macro-proposition Γ , of a sub-sequence of E .

This rule suggests that there is a necessary rule ordering of macro-rules, just as in the syntactic transformation of generative grammars: the deletion rule can apply only if we already have macro-structures of previous parts of the sequence. To stay within the same transformational terminology, we may say that this rule is an example of 'semantic tree pruning'.

Let us *pie* another example of this rule:

- (5) (I needed some olive oil, needed some olive
So I went to the store and oil, So I went to the
bought some, There was a store and bought some,
sale on olive oil, We had a We had a good Italian
good Italian meal . . .) meal . . . >

The proposition 'There was a sale on olive oil' may be deleted because it is irrelevant to the topic of eating Italian food and needing olive oil for it: the sale does not 'follow' from needing olive oil, and hence does not determine buying it,

nor having Italian food. If the sale would condition these facts, the proposition representing it would not be deleted.

A characteristic of both rule I and rule II is that the information from which the macro-structure is abstracted cannot be recovered. However, other cues (i.e., other than the macro-structure) may allow retrieval of detailed information.

The next macro-rule, INTEGRATION, deals with the possibility that macro-information may be directly expressed in the discourse. This rule and the next one are interesting from the point of view of discourse processing because they organize and reduce information that is coherently related. According to the INTEGRATION rule, the more specific information of the passage may be deleted by the simple fact that its global information has already been expressed in the text by the proposition that also serves as a macro-proposition. This proposition may be selected as being important to the discourse. Formally, if a passage yields a macro-proposition that is the same as a proposition in the discourse expressing this macro-structure, the latter proposition may be deleted. An alternative way of stating it is that all detailed information may be deleted which somehow has been integrated into another proposition of the discourse. We will follow the second alternative for convenience.

How does the integration take place? The answer to this question will be simplified here: we will say that a proposition p may be 'integrated' into a proposition Q if p denotes either a normal condition, a normal component, or a normal consequence of the fact denoted by Q . While formal definition of these terms will not be attempted, we must at least consider what is generally meant by "normal." The notion of normality, which has very important implications in linguistic and cognitive semantics, will be taken as denoting truth in most possible worlds compatible with our actual world. This means that given some other facts, a normally co-occurring fact is expected. A condition, component, or consequence may have different 'strengths', ranging from possibility via probability to all kinds of necessity. Thus we get 'possible condition', 'probable condition', 'necessary condition', 'possible component', 'probable component', 'necessary component', 'possible consequence', 'probable consequence', and 'necessary consequence' (for definitions of these notions in terms of actual theory and formal semantics, cf. van Dijk, 1977).

Consider some concrete examples. A normal condition for smoking a pipe is that I light it (although I may imagine some worlds where somebody else lights my pipe, or where it is lit by putting it in the sun, under a magnifying glass, etc.). Under the circumstances the condition is necessary because smoking a pipe implies that my pipe is burning and burning tobacco necessarily presupposes lighting. Similarly, drawing my pipe or puffing smoke are normally necessary components of pipe smoking. The point of all this, of course, is that given the proposition 'I smoke a pipe', the other propositions may be integrated into this proposition, because the detailed information is weakly implied by it. The macro-proposition allows us to describe detailed actions and events at a

more global level, *where* typical co-occurring sub-events need not be mentioned. A normal component of reading a book is that I turn the page, a normal consequence of cashing a check is receiving money in return — by application of the INTEGRATION rule, these normal components and consequences need not be mentioned.

It is at this point where our conventional knowledge of the world, i.e., our frames, must come in, because they determine what is normal in a given culture in a given situation. We will come back to the interaction of frames and macro-structures below.

The idea of a normal or *expected* fact, relative to some global fact, is crucial here. We are not allowed to integrate propositions which do not have this property. Consider the proposition sequence, 'John fell from his chair. John broke his neck'; we may not integrate either of the propositions into the other, neither as a normal condition nor as a consequence, although the first event causes the second in this particular case. Such propositions have a particular informative function, because they cannot be inferred from the other proposition.

Given these observations, let us now try to formulate a macro-rule of INTEGRATION, which may also be called SELECTION, because it selects macro-propositions from the text base.

(6) INTEGRATION (M-III)

Given a sequence of propositions $E = (p_1, p_2, \dots, p_n)$, $n \geq 2$, if there is a proposition p_i , such that for each proposition p_j , $V(p_j)$ is either a normal condition, a normal component, or a normal consequence of $V(p_i)$, then we may substitute p_i for E .

The expression $V(p)$ denotes the fact denoted by the proposition p (in some possible world); i.e., V is a valuation function assigning a fact to an expression of language.

Another interesting by-product of this rule is that we now have a formal means to determine that some sentence (or expression) is thematic or topical. A sentence or clause is thematic if it expresses a macro-proposition of the discourse. Let us give a typical example of this rule:

- (7) (John went to Paris yesterday.
 He took a cab to the station, **John went to Paris yesterday**
 He bought tickets, He took
 the train to Paris ...

Now consider a discourse in which the propositions are compatible components of some action, but neither obligatory nor typical. For example, suppose in (7) there is the additional proposition: "John smoked a pipe (in the train)." For such cases we may liberalize rule M-III somewhat and allow propositions compatible with normal propositions also to be integratable. How-

ever, such a proposition would be eliminated at a macro-structural level by the DELETION rule, because it is not an interpretation condition for other propositions of the sequence. Whether John smokes a pipe or not, the action of traveling to Paris will be accomplished anyway, which would not be the case if, for example, he failed to buy a ticket.

The last macro-rule we propose, CONSTRUCTION, is closely linked to INTEGRATION, and they might be considered variants of each other. The interesting difference is that CONSTRUCTION has no input proposition that organizes other propositions. Instead, a sequence of propositions is directly replaced by a macro-proposition, under the same conditions as in INTEGRATION. That is, we construct information at a more global level on the basis of micro-information in the text base. Typically, the micro-propositions represent conditions, components, and consequences of the (global) fact denoted by the macro-proposition.

(8) CONSTRUCTION (M-IV)

Given a sequence of propositions $E = \langle p_1, p_2, \dots, p_n \rangle$, $n > 2$, if there is a proposition r such that for each p_i , $V(p_i)$ is a normal condition, or a normal component, or a normal consequence of r then substitute r for E .

Both M-III and M-IV satisfy the general entailment condition by general meaning postulates or by the structure of the relevant names involved. That is, if E has a subset of propositions denoting necessary properties of the macro-proposition, then the macro-proposition is entailed by E , or by p_i which is equivalent to r . Because non-typical, but globally irrelevant, information may be part of E , the entailment relation does not hold in the reverse direction. However, given a macro-proposition, our frame knowledge will allow us to infer at least the subset of necessary propositions of E . Whereas in rules M-I and M-II the information of the text base was lost through the application of the macro-rules, the nature of M-III and M-IV allows us to reconstruct a large part of the micro-information. This has the important cognitive consequence that micro-information that has already been integrated or constructed and hence suppressed may be retrieved. In this sense macro-propositions not only organize and reduce information, but may also serve as retrieval cues.

A number of further complications must be resolved, one of which concerns the entailment condition. A text base may not contain sufficient information to be able to unambiguously apply the rules such that the resulting macro-proposition is entailed by the sequence. By the pragmatic principle of informativeness, we may delete a great number of propositions 'following' from expressed propositions. Thus, we may say that 'John showed *his* ticket to the conductor' even if no proposition such as 'John bought a ticket' is expressed, but only that he took the train to Paris. As we have seen above, such 'missing link' proposi-

tions are postulated in the explicit text base. However, even propositions that would not occur in the explicit text base would in principle be needed in order to prove entailment (e.g., the proposition denoting that John arrived in Paris). Thus, a macro-proposition must sometimes be constructed on the basis of incomplete knowledge. This means that macro-structure formation is not exclusively deductive but is also based on induction. As in visual information processing, default values ('missing facts') are assigned in order to infer a macro-structure. If we see somebody going into the station, buying a ticket, and going to the platform, we inductively infer that he takes the train, by the fact that he has accomplished the normal preparatory actions of taking the train, and by a general principle of rationality saying that if possible we continue to execute some intended action. If the normal course of events does not take place, the propositions denoting a disrupting event cannot be deleted, because they are important relative to the global action (e.g., 'But the train was in an accident, and John was killed').

The macro-rule of CONSTRUCTION is perhaps most characteristic of all macro-rules. It organizes micro-information by combining sequences of propositions that function as one unit at some macro-level; it reduces information without simply deleting it; and it introduces information at the macro-level that is 'new' in the sense of not being part of the text base or entailed by individual propositions of the text base.

We conclude this section with some linguistic facts that support the hypothesis that discourses should be assigned macro-structures according to the rules formulated above (cf. van Dijk, 1977).

First, macro-propositions can be expressed in the discourse itself, namely as topical sentences. Such sentences have peculiar properties. They are not in general connectible with other propositions of the discourse, because connectedness implies relatedness of facts at the same level of description. Thus we may have

(9) John went to the station *and* bought a ticket for the train.

but hardly:

(10) John went to Paris *and* he went to the station.

The only way to 'connect' the clauses of (10) would be by a specifying *so*:

(11) John went to Paris. So, he went to the station, -

Another linguistic fact is that we may use pronouns and definite articles presupposing the presence of macro-propositions that are not expressed by the discourse. After the description of a bank robbery we may have a definite noun phrase in a sentence like:

(12) The robbery was the third in town in one week, -

even if no co-referential expression denoting a robbery has occurred in the previous part of the discourse. The same holds for pronouns:

- (13) The police declared that they could not have prevented *it*.

Finally, we may have macro-connectives in the discourse, which do not link successive propositions, but rather link a proposition with a whole sequence, or whole sequences with whole sequences. This is possible only if we assume that the sequence is represented as one proposition at some level of macro-structure. After the same description of a bank robbery the discourse might continue in the following way:

- (14) *But*, an old lady had remembered the license number of the car, so that the robbery were arrested the same evening.

More generally, the role of macro-structures is evident in the coherence of complex sentences and discourses. We have assumed that connectedness, and linear coherence in general, is relative to a topic of discourse. The topic of discourse is a semantic structure which we take to be identical with the macro-structure of the discourse. Thus the connectedness conditions for a sentence like 'John bought a ticket' depends on whether the topic of discourse is 'John took the train' or 'John was going to the movies'. So, under this constraint we judge (15) to be acceptable, but not (16):

- (15) John went to the station and bought a ticket.
 (16) John went to the station and fell asleep.

The macro-structure thus defines the kind of possible events and actions which may take place in an episode.

CONVENTIONAL SUPER-STRUCTURES

Discourses may be assigned another kind of global structures, which we will call super-structures in order to distinguish them from semantic macro-structures. One well-known super-structure is a narrative. A discourse expressing a narrative super-structure will be called a story. A story is a discourse containing action sentences with specific pragmatic conditions.⁵

See van Dijk (1976b) for references to work in narrative theory of such anthropologists, linguists, and literary theorists as Propp, Bremond, Barthes, Todorov, Dundes, Maranda, Colby, and many others. Pragmatic properties of narrative are also discussed in van Dijk (1975b). Our narrative categories are based in part on ideas by Labov and Waletzky (1967). See van Dijk (1975a) for an analysis of a story and experiments carried out in collaboration with Kintsch (see also Kintsch, this volume). For a somewhat different approach to story analysis, see Rumelhart (1975) and Thorndyke (1975).

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Narrative super-structures are conventional: the rules of story-telling belong to our general knowledge of language and culture shared with other members of a community. Although narrative structures may be expressed by natural discourse, they are not themselves linguistic: the same narrative may be expressed by images, for example. The rules and categories of narrative should be formulated in an independent theory of narrative. Some tentative examples of narrative formation rules are:

- (17) NARRATIVE \rightarrow ACCOUNT + MORAL
ACCOUNT \rightarrow SETTING + EPISODE
EPISODE \rightarrow HAPPENING + EVALUATION
HAPPENING \rightarrow COMPLICATION + RESOLUTION

Details are omitted (some categories are recursive, for example), and no differentiation is made among various sorts of narrative.

In order to be able to express a narrative structure in a discourse, it should somehow be mapped onto one of the levels of representation of the discourse. Since the categories involved clearly do not dominate isolated sentences, we must assume that conventional super-structures are mapped onto semantic macro-structures of the discourse. These mappings assign specific functions or roles to macro-structure propositions. Thus a macro-proposition such as 'was very hot' may function as a SETTING for some EPISODE such as 'We went to the beach', etc.

Narrative categories require specific properties of the macro-propositions assigned to them. For example, a SETTING will usually be assigned a state or process description, whereas a COMPLICATION must be an action or event proposition, and a RESOLUTION must be an action proposition. It is clear that such constraints can be formulated only at the macro-level, because the individual propositions in the text base fragment dominated by a RESOLUTION need not all be action propositions. However, the macro-rules must yield an action proposition.

Finally, some categories have constraints at the borderline of semantics and pragmatics. For example, there is a semantic/pragmatic requirement that the COMPLICATION actions or events must be 'important' or 'interesting'. Thus, my opening the door of my house will not in general constitute a possible COMPLICATION in a story, whereas the train having an accident will constitute such a category, and hence become a pragmatic condition for provoking interest for the story.

Since both the semantic macro-rules and the discourse-typological rules of narrative are recursive, we may have narratives embedded in narratives: what at some level of description is itself a narrative may become part of a COMPLICATION at a higher level. This is especially the case in all kinds of artificial narratives, from folktales to long novels, as opposed to our everyday small stories, which may be called 'natural' for several pragmatic reasons.

Super-structures are organizing principles of discourse. They have a hierarchical character, roughly defining the 'global syntax' of the text. By contrast, the macro-structures define the 'content' of the text. In certain kinds of narrative, such as folktales, this content may be conventional (e.g., 'The princess is abducted by the dragon', or 'The hero is helped by a witch'). The same holds for our modern 'folktales' (e.g., James Bond stories and films).

Super-structures may determine the application of macro-rules, because they place constraints on resulting macro-propositions. For example, in some parts of a story we should abstract from state descriptions but not from action descriptions. Similarly, some action propositions may be more relevant to the narrative structure than other action descriptions.

What has been said about the conventional 'gene' of narratives also holds, *mutatis mutandis*, for other discourse types, e.g., arguments, advertisements, newspaper reports, propaganda, and psychological papers. In all cases the constraints involved operate globally, both on the global syntax of the macro-structures and on their specific content. Pragmatic properties of communication are always involved, and these may range over global information of the discourse. An advertisement may thus be advice or exhortation to buy some product. This advice need not be micro-structurally expressed in the discourse, but may exist only at some macro-level of semantic and pragmatic description.

FRAMES AND MACRO-STRUCTURES

Discourse processing at various levels depends on our conventional knowledge of the world, as it is represented in structures called frames.⁶ Linear coherence, for example, depends on interpolated propositions that remain implicit in the expressed discourse and are inferred from the other propositions of the discourse with the help of lexical meaning postulates and frame information. Similarly, the global coherence of discourse as defined by the macro-structure is established with frame knowledge about typical situations and events and actions. In order to account for the interaction of frames and macro-structures, we must know how frames are organized, what their typical contents are, how they are put to use, and how they can be transformed by knowledge acquisition. Although frame 'theory' has been developing rapidly in the last few years, a number of basic problems have not yet been formulated, let alone solved. A serious application of frame theory in cognitive models presupposes answers to such questions. Some basic issues and some tentative sketches for more explicit answers will be now formulated.

⁶ We refer to recent work of Minsky (1975) and Charniak, Schank, Winograd, and others collected in Bobrow and Collins (1975), but will not comment on individual proposals (made under various labels, e.g., 'scripts', 'demons', 'scenarios', etc.).

Frames are knowledge representations about the 'world' which enable us to perform such basic cognitive acts as perception, action, and language comprehension. At some higher level the content of a frame is fixed, but its lower level terminals can be accommodated to the properties of information input. We may see a chair from multiple angles, but we still see it as the same chair. Frames may be thought of as conceptual networks that contain embedded pointers to other frames. It has been emphasized that a frame not only contains 'static' data, but also 'dynamic' procedures, describing how to act in certain circumstances. Apart from some sketches, no complete frame has as yet been formulated and put to use, although there are some computer programs handling simpler, ad hoc, frame-like structures.

Frame theory requires clarification on a number of points. First of all, the empirical foundations of the theory deserve some attention. That is, what is the precise status of frames, what do they represent, and how are they used, acquired, and transformed? Secondly, it should be made clear how frames are not only cognitively but also socially determined, as Bartlett emphasized.

The most pressing question is: under what conditions can a piece of knowledge be said to constitute a frame? In other words, the theory must specify what is and what is not a frame. If everything in our semantic memory is a frame, the notion loses its interest because it would fail to discriminate a specific enough set of conceptual structures. In such a case, the notion of frame would collapse with the notion of 'concept' or 'conceptual structure' that was discussed in the psychological and artificial intelligence literature of some years ago. Even if we take frames to be 'organizing principles' of semantic memory, we still should distinguish between concepts on the one hand and conceptual operations of organization on the other hand. Let us, therefore, give some provisional conditions which a more specific notion of frame should satisfy.

Although notions such as concept and frame are intended here as cognitive structures, it seems useful to mention the philosophical and logical approach to the notion of a concept, as it is used in current formal semantics (cf. Montague, 1974). A concept is a function from possible worlds to certain properties of these worlds, e.g., individuals, relations, or facts. Thus, we have individual concepts, property or relation concepts, and fact concepts (propositions). For a given possible world such a function may be assigned values, namely the instantiations of the concept in that world. The concept I_{chair} has many actual values in our own possible world, whereas the concept $I_{\text{flying saucer}}$ probably has no value in our actual possible world. However, a science fiction writer may imagine worlds where the concept has a value. A concept, thus, is a possible object. Concepts which have no values in any world are impossible objects, e.g., square circles. Similarly, I_{red} is a possible property, I_{love} is a possible relation, and $I_{\text{a boy (is) ill}}$ is a possible fact. Individuals satisfying a concept in some world are not extensional in the proper sense of being spatio-temporally unique. They are themselves constant functions over a series of situations: Peter will remain the

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'same' Peter during his whole life, whatever the biological changes in his body or the cognitive changes in his mind. Similarly, the particular individual is interpreted as an instantiation of one or more concepts: Peter may instantiate the concepts of [I_{man}, I_{brother}, I_{father}, I_{lawyer}, or I_{lover}], for example.

Concepts themselves may be seen as certain operations on 'semantic space'. They select a certain number of property concepts and combine them into a unit, such that the values of that unit in some possible world are discrete, distinguishable, and mostly continuous objects. These objects may be complex. They may have parts or properties which also actualize a concept. But the complex concepts also satisfy the criteria of discreteness, identifiability and spatio-temporal contiguity. A party is a complex unit, but we may distinguish it from other parties and from non-parties. The criteria involved clearly also have a cognitive bite. They constitute the basis of many kinds of cognitive processing: perception, understanding, thinking, action, etc.

Due to the necessities of perception, action, and natural language, we inductively acquire the relevant conceptual picture of our world (and of the possible compatible worlds) and thus construct our semantic memory. The cognitive processes of interpretation are based on the identification of values of a concept stored in memory. It is assumed that the actual identification of input data takes place in episodic memory. Although detailed insight into the processes involved is still lacking, the general picture as sketched here seems fairly uncontroversial.

A second set of assumptions regards the organization of our conceptual system. Clearly, the concepts we know do not constitute a non-ordered set. The concept of 'boy' is somehow related to the concept of 'male', and the concept of 'chair' to the concept of 'furniture' and the concept of 'sitting'. Note that these relations, if part of semantic memory, must themselves be general and essential, i.e., hold in any possible world. If a boy were not male, he would no longer be a value of the concept 'boy', but the actualization of some other concept, for which a name may be lacking. On the other hand there are other relations which constitute possible but nonessential facts, e.g., between 'boy' and 'ill' (see Kripke, 1972, and Rescher, 1975); these relations would not be considered part of semantic memory.

Concepts may be complex in the sense of being composed of other concepts. Thus, both the notions of a 'house' and of 'building a house' are complex in this sense. Complex concepts are not arbitrary: they have upper and lower bounds. Although, physically, any concrete object may be decomposed into terminal objects such as atoms or sub-atomic particles, this is not the case cognitively. A chair has legs, a seat, and a back as cognitive lower bound constituents. Similarly, we have the complex concept of a house, but no general memory representation for the house + its garden + the part of the street which it is on + the part of air/sky in and around it, although we have a conceptual unit for a whole street or a whole town. It is at this point in the foundations of concept

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formation theory where the notion of frame is introduced. Thus, while we may take any frame to be a conceptual structure, not any concept is a frame. We will attempt to draw the distinction.

Most examples of frames mentioned in the recent literature pertain to relatively complex conceptual structures such as rooms, restaurants, supermarkets, and birthday parties. Hence we might conclude that a frame is a higher order organizing principle for various kinds of concepts: objects, properties/relations, and facts. However, the notion of complexity is relative: a restaurant is certainly more 'complex' than a 'door', but the difference is one of degree or level. At a certain level of description the door has essential or typical components and properties/relations. However, there seems no point in assigning frame status to doors. The typical properties of doors are accounted for by the concept of 'door', but this concept does not organize our knowledge beyond these typical properties. In this sense, though, we should also treat a restaurant as a concept and not merely as a frame. The unit 'public place where one can eat' is not significantly different from the unit 'object covering an entrance'. It follows that the definition of a frame must be sought along other dimensions.

We propose that frames define units or chunks of concepts which are not essentially, but *typically*, related. Some intuitive examples may clarify this point. Conceptually, there is no immediate or essential relation between the concept of 'table' and the concept of 'cereal', nor between 'soap' and 'water', or between 'waitress' and 'menu'. They are distinct and do not presuppose each other. Yet, they are organized by the frames of 'breakfast', 'washing', and 'restaurant', respectively. They usually denote certain normal courses of events or courses of actions involving several objects, persons, properties, relations, and facts. These kinds of denotata, or values, of frames will be called *episodes*. It is in this sense that frames are higher-level organizing principles. They unify concepts of various types and at various levels of representation under the constraint of typicality and normality. Formally, this means that episodes have the properties as specified by the frame in most possible worlds compatible with the actual possible world.

Frames are not merely chunks of knowledge, but units of conventional knowledge according to which mutual expectations and interactions are organized (cf. Lewis, 1968). Thus, on the one hand the concepts of a 'restaurant' or a 'party' form a network of necessary properties. On the other hand the frames associated with these concepts involve a whole series of objects, events, and actions that are typical parts of restaurant or party episodes. In this sense we may have a concept of a restaurant or party, but giving a tip or bringing a present belongs to the frame information determining normal interaction. This distinction between concepts and the conventional organization of concepts in frames is still not very explicit, but it seems clear enough to give frames a more specific function in a theory of cognitive information processing. This interpreta-

tion of frames also provides potential links to social psychological notions such as communication and interaction, and may help to account for the role of social constraints in conceptual information processing.

A theory of frames should specify the explicit structures and functions of frames. A frame may be formally represented as an ordered n -tuple of propositions and propositional functions. These propositions denote both states (properties and relations) and events or actions. Propositions may be conditional (p happens, then it is possible/probable/necessary/obligatory that x does q). Therefore, procedures also may be represented or reconstructed by rules of inference.

Since frame information may be highly complex, it should itself be organized. At this point the macro-rules discussed above may play a crucial role. They define the constituent levels and sub-units of each frame. That is, at some level of the 'eating in a restaurant' frame, a person will be expected to 'have a meal', but at a lower level, he will order the meal, eat and drink in various stages, etc. Similarly, the frame of 'traveling by train' at the highest level involves 'taking a train', at a lower level 'going to the station', 'buying a ticket', 'going to the platform', etc., and at a still lower level 'ordering a ticket', 'paying for the ticket', etc. Thus, each sequence of actions/objects is organized at a higher level by a macro-proposition. We surmise that the highest macro-level of a frame is identical with the concept of the frame, defining the essential content of the frame.

Such a frame organization is necessary in order to explain the functions of frames in cognitive processing. When I organize a party, I need not actualize the whole supermarket frame because I briefly go to the supermarket to get some peanuts for my guests. In other words, the functioning of frames is level-specific, depending on the structure of the text base or the course of events to be processed. In a situation where 'getting peanuts for my guests' is the topic, the only aspect that is relevant is the success of the act realizing my purpose, i.e., getting peanuts. The supermarket is involved only as 'the place where one can buy food', hence at a rather high level of the macro-structure of the frame. The full supermarket frame would become necessary in discourse comprehension only if the concept of supermarket itself were the topic. If the party frame is topical, then parts of other frames may be activated, namely those parts that denote conditions, components, or consequences of the "topic" frame. Getting some peanuts is a condition for having peanuts as a part of a party frame.

From this informal discussion about the status, structure, and functioning of frames, it emerges that frames and macro-structures are closely related but entirely different notions. Both organize complex semantic information. Frames, however, are conventional and general. Most members of a society or culture have approximately the same set of frames. Macro-structures do not have this character. Instead, they are ad hoc information, i.e., the particular global content of a particular discourse. Only the operating macro-rules are general, as cognitive principles for the organization and reduction of any kind of semantic

information, both of conventional frame knowledge and of the meaning structure of a particular discourse.

Frames and Macro-structures in Discourse Comprehension: An Example

We will give an informal and partial analysis of a story passage in order to illustrate the principles involved in using macro-rules and frames. A full discourse analysis, at all levels, cannot be given and is not necessary here. Our example is taken from a crime story, *Just the Way It Is*, by James Hadley Chase (originally published 1944, Robert Hale & Co., London; Panther Books edition, 1975, p. 28).

The preceding context of the passage may be expressed by the following summary. The summary expresses the macro-structures of the previous part of the story:

Context description:

Ciare Russell is the main reporter of a small local newspaper in a town which has had its best time. Her friend Peter has arranged to introduce her to his friend Harry Duke, a local gambler with a bad reputation.

Discourse (beginning a new chapter):

1 Harry Duke watched them come in from *his* corner at the end of the bar. He looked
 2 at Ciare curiously, then he put his glass down slowly on the polished counter. She
 3 was standing in the doorway with Peter just behind her and he saw her face turned
 4 at an angle and at the same time he saw the strange thing about her. As he looked at
 5 her he felt a thickness in his throat.
 6 When they saw him and came across, he was careful not to stare at her, although he
 7 wanted to. He kept his eyes on Peter, ignoring her until they reached him and then
 8 he looked at her, meeting her dark serious eyes and then looking away.
 9 "Well, here we are," Peter said, looking like a dog with two tails. "Harry, this is
 10 Ciare. I want you two to like each other."
 11 Ciare was startled. She hadn't expected Duke to be like this at all. She could see
 12 now why Peter admired him. It irritated her to find him so untrue to type. The
 13 short black hair and the close-clipped moustache were unexpected. So were the
 14 steady green eyes that looked through her so searchingly. She was offering her hand
 15 before she realized her mistake and he had taken it.
 16 "Helio," he said, "I've been waiting a long time to meet you".
 17 (...)

In order to be able to understand this passage a reader must activate certain frames, namely, those of MEETING, INTRODUCTION, FALLING IN LOVE, and BAR. Of course, the INTRODUCTION frame is a conventional, optional part of the MEETING frame, and intuitively speaking, the BAR frame only plays a secondary role. As we see from the context description, the MEETING/INTRODUCTION frames had already been activated by the verbal context, that is by the intention of these complex conventional actions. The passage is to be interpreted as the description of an episode which is a possible instantiation of

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the respective frames, that is, as a subset of propositions which are identical with lower-level propositions of the frames. Other propositions denote specific properties of the episode and define the discourse as a particular 'message'.

The passage is a fragment of a story and hence must satisfy the constraints of narrative structure. The narrative involved is artificial, which explains a certain number of properties which are not found in everyday casual recounting of personal experiences. The fragment is part of the COMPLICATION category, in which Clare's falling in love with Duke is a condition for the destruction of her relation with Peter, and at the same time as a preparation of the RESOLUTION in which Duke helps her to fight corruption and crime in town.

The interesting feature of this example is that the topics, defined by the macro-structures and the frames, are not themselves expressed in the passage. That is, a reader must construct macro-structures in order to be able to understand that the passage is about a meeting, an introduction, and the event of falling in love.

Since the meeting is topical for this passage, details may be described. The first component to be expressed is the place of the meeting, a public bar. The BAR frame, however, is addressed only at a rather high level. A full description of the bar and of typical actions in bars is not necessary. All that is needed is the fact that we can meet people in bars, wait for them, and have a drink. We need more than the concept of bar, however, in order to be able to interpret the phrase *the polished counter*, with a definite article, which means that there must be a proposition in the explicit text base introducing a particular counter. This proposition is typically based on our frame information about bars.

The other details pertain to properties of the meeting: seeing each other, approaching each other, observing each other, forming impressions and attitudes toward each other, and speaking to each other. These facts are conventional parts of the episode and hence are covered by a frame.

At the same time, the FALLING IN LOVE frame is activated, denoting conventional properties of the MEETING episode; to be curious, to watch somebody closely, to feel a thickness in one's throat, to avoid looking somebody in the eyes, to be startled, to understand a third party admires the other, to be embarrassed, to be out of control, etc. The propositions denoting these facts are expressed in the passage or entailed by propositions of the passage.

As part of the MEETING frame we finally have the INTRODUCTION frame, which includes the proposition 'if *X* introduces *Y* to *Z*, then *X* and *Z* know each other, and *Y* and *Z* do not know each other'. Furthermore, the introduction must involve certain standard discourses, as expressed here in lines 9-10 and 16.

A further point of narrative interest is the perspective of the description. Lines 1-8 are described from the point of view of Harry Duke; lines 9-10 have a neutral point of view, that of the observer narrator; lines 11-15 represent Clare's point of view; and 16 is again neutral. This indication is necessary in

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order to be able to describe and explain internal events such as thoughts and feelings, which are the conditions for certain actions.

Finally, there is perhaps another frame involved, namely that of GOOD GUY/BAD GUY, typical in conventional narratives like crime stories. From the context it would follow that Harry Duke would actualize the 'bad guy' concept, but the description of his appearance and his actions (from the point of view of Ciare) indicates that a GOOD GUY frame must be activated. This frame change must be expressed in the discourse. Here the concepts of 'startled', '(not) expected', 'untrue to type' are used to mark this change in the current expectations of a person with respect to the typical properties of another person in a certain role.

Given this kind of frame information, the macro-rules can now operate on the passage. The reader first should identify the topic of this passage, because it is the beginning of a new chapter, and the respective chapters do not always continue the topic of the previous chapter, but may change place, event, and characters involved. From the first sentence, however, the reader may infer that the planned meeting will now be described, since both Harry Duke and Ciare and Peter are referred to by a seeing relation between Harry and the couple, and then between Harry and Ciare. Since the reader knows Harry and Ciare have not yet met, this event may be the initial event of the MEETING episode, and the reader will hypothetically construct PETER INTRODUCES CLARE TO HARRY as a first macro-proposition. This hypothesis will be confirmed by the rest of the passage. The next sentence (line 2) implies that Harry is particularly interested in Ciare. Following sentences imply that he has particular interest in her appearance, and then lines 4-5 indicate that this appearance makes an impact on Harry. By macro-rule IV, CONSTRUCTION, these normal constituent components allow the construction of a macro-proposition such as HARRY IS IMPRESSED BY CLARE. The same holds for lines 11-15, which allow the construction of the macro-proposition UNEXPECTEDLY CLARE WAS IMPRESSED BY HARRY. The other propositions express the components of the frame 'substrate' of the passage, MEETING/INTRODUCTION, and yield, also by rule IV, PETER INTRODUCED CLARE TO HARRY, which is a normal component of the higher-order macro-structure CLARE AND HARRY MET. This means that at a higher-level description of the discourse the specific introduction may be integrated. The implication of this assumption is that the specific introduction will be forgotten first. Finally, both macro-propositions denoting the facts that Ciare and Harry were impressed by each other's appearance are conventional constituents, i.e., normal conditions of the FALLING IN LOVE frame. Thus, at a higher level, the macro-proposition HARRY AND CLARE FELL IN LOVE WITH EACH OTHER may be hypothesized to be true. This hypothesis is confirmed in a following chapter, in which Clare 'reviews' the meeting and her reactions to it.

Part of the FALLING IN LOVE frame is that initially the involved partners do

not show their inclination openly or try to fight it. This component is expressed by the sentences in fines 6-8 and line 15, respectively. The concepts of 'man' and 'woman' occurring in the FALL IN LOVE frame may activate the respective MAN and WOMAN frames, in which typical appearance and behavior is represented. In our passage the MAN frame is necessary to interpret the sentence in fines 13-14, whereas the more general HUMAN frame allows the occurrence of eyes, hands, etc. Note that in general these frames need not be activated at this precise level of representation, but the FALLING IN LOVE frame presupposes that the partners have given specific attention to the details of each other's appearance. We see again that a frame is addressed as a basis for the application of the macro-rules, and that the level at which the frame is addressed depends on the constraints of the cognitive context. The only parts of the frame that are activated are the propositions that are normal conditions, components, or consequences of the propositions of the discourse.

Our characterization, in this stage of research, has been highly informal. A more explicit account would have required a translation of the passage into some formal propositional representation, a formulation of the macro-rules as given earlier, and finally a full description of the structure of the respective frames and other conceptual structures determining the interpretation of the text base of this passage. The resulting macro-structure would in that case be explicitly derivable.

Instead of such a formal treatment, we will simply represent the respective macro-levels by sequences of propositions which are appropriately connected. We see that the first-level macro-structure is subject to further macro-interpretation, and even a third-level abstraction seems possible. The macro-propositions of levels 2 and 3 are followed by the macro-rules involved as well as the macro-propositions to which they apply. For reasons of simplicity we have omitted these indications for the first level, referring to the informal description given above (see van Dijk, 1976a, 1977, for more precise macro-analyses). We thus obtain the following macro-representations:

Level M-1

P_1^1 HARRY DUKE LOOKS AT CLARE
 p_i HARRY DUKE IS IMPRESSED BY CLARE
 p_i HARRY DUKE AND CLARE-PETER APPROACH EACH OTHER
 p_4 PETER INTRODUCES CLARE TO HARRY DUKE
 p_i UNEXPECTEDLY CLARE IS IMPRESSED BY HARRY DUKE
 P_6 HARRY AND CLARE GREET EACH OTHER

Level M-2

P_1^2 HARRY DUKE MEETS CLARE (M-IV, (Pi, PI, Pi>)
 P_2^2 HARRY DUKE IS IMPRESSED BY CLARE (M-III, (Pi, Pi>)
 F_3^2 CLARE IS IMPRESSED BY HARRY DUKE (M-I, (Pi >)

Level M-3

pi HARRY DUKE AND CLARE FALL IN LOVE WITH EACH OTHER
(M-IV, , PS))

DISCOURSE PROCESSING: SOME HYPOTHESES

In the previous sections several remarks have been made about the possible implications of macro-structure theory for a processing model for discourse. These implications apply not only to discourse comprehension, but also to the planning and execution of complex discourse, integration into semantic memory, forgetting, reproduction, summary production, recognition, question answering, paraphrasing, and solving problems about the text. We will briefly state a number of hypotheses regarding these processing implications.⁷

First of all, it will be assumed that in discourse comprehension fragments of the morpho-phonological and syntactic surface structure of the sentence sequence are stored only in short-term memory to construct a proposition sequence. Only general stylistic properties, such as sentence length or complexity, use of particular words or phrases, and specific transformations may be stored in the episodic memory for the particular discourse (cf. Kintsch, 1974).

Secondly, it is assumed that beyond a limited number of propositions, the proposition sequence of the text base is not fully accessible for recall. This limit is somewhere between 20 and 50 propositions, depending on linear coherence properties, familiarity of the topic, the degree of conventionality of the sequence, and so forth. The limit for recognition is much higher. Even if we no longer would be able to produce a certain proposition, we are able to recognize that it was part of the text base if it is later needed as a presupposition for another proposition. In general, the reader will not be able to distinguish which of the propositions of the explicit text base were actually expressed in the discourse. But the pragmatic rules enable him to assume that only non-trivial or non-general propositions will have been part of a natural discourse.

Given a sequence of assigned propositions, the reader will make hypotheses about the relevant macro-structure proposition covering the sequence by applying the macro-rules to the sequence. This process may be facilitated by the expression of macro-propositions in the discourse, as titles, thematical sentences, or announcements of complex events and actions.

⁷It is impossible to specify here the various sources, beginning with Bartlett (1932), from which our insights about cognitive processing of discourse derive (the bibliography on this particular topic has more than 100 titles). See surveys and references in Meyer (1975), Thorndyke (1975), and van Dijk & Kintsch (1977). The results about macro-structure and its influence in recall and summarizing come from Kintsch & van Dijk (1975), van Dijk (1975a), and van Dijk & Kintsch (1977). See also Kintsch (this volume).

Macro-structure formation takes place in the course of reading the text, not a posteriori. The same holds true for the assignment of conventional categories to the macro-propositions. Both the assignment of macro-structures and of conventional super-structures is recursive. As soon as a first level becomes too complex, a second level is formed, and so forth.

This macro-structure is available when it is necessary to explicitly summarize a text. Immediate summarizing of the discourse only involves the reproduction and expression of some level of macro-structure, with the usual discourse output constraints of a pragmatic nature.

Whatever is actually retained from the text base and stored in episodic memory is organized by the macro-structure of the passage or of the whole discourse. In this sense, it is assumed that the macro-structure also serves as a retrieval cue. If we know that *X* fell in love with *Y*, inverse application of the macro-rules enables the reconstruction/recognition of the propositions '*X* met *Y*' and '*X* was impressed by *Y*', and then possibly some details of the meeting (where did the meeting take place, who was present, how did they behave, etc.). If such information is no longer retrievable, it is supplied by the most probable components of the frames associated with the concepts of the relevant macro-structure proposition. Of course, this may lead to false recognition.

The macro-structure is also the basis for recall of the discourse immediately after presentation. The macro-structure is directly available in episodic memory. It then yields, by inverse macro-rule application and recognition, access to lower-level macro-structures and possibly to some text base propositions if the discourse was not too long.

The first forgetting phase involves impaired access to the information available by inverse application of the macro-rules on the macro-structure. Propositions that are implied by the macro-structure (as in tales III and IV) should be derivable. But the information that does not belong to the frame and is not relevant for the interpretation of the rest of the discourse might not be accessible. At the end of the first forgetting phase, the topmost macro-structure of the discourse is still available. In the second forgetting phase successive infractions on the macro-structure take place. These may be highly personal, sometimes depending on arbitrary attention and interest factors: "it was a story about a woman reporter," or "I remember some violent fights," etc.

The macro-structure in the first phase constitutes the basis for permanent knowledge formation, because this requires full propositions, not merely fragments of propositions. The subsequently degraded information seems inadequate for this purpose.

Macro-structures may also constitute 'plan for speaking'. They may represent the global idea of a discourse that a speaker wants to convey. In actual execution, lower-level macro-structures will be formed, as well as the respective sequence of propositions dominated by them. Of course, this process allows for revision of the original macro-structure, and of the lower-level macro-structures constructed during execution (e.g., when the speaker sees that his hearer is not

interested in a certain topic, or that his hearer will be offended). The actual production of syntactic and stylistic structures of sentences is determined by short-term planning, under the scope of the text base fragment to be expressed and the various pragmatic rules of the state of the context.

Macro-structure formation is a highly complex process, so it can hardly be expected that effective comprehension exactly follows the rules formulated above: expedient *strategies* are used in the global interpretation of discourse. These strategies are probabilistic: they are based on more or less warranted expectations of the language user. For instance: if we read that somebody is going to the train station, we might construct the hypothesis that he will take a train. We might expect him to begin some travel action, and this then is the provisional topic of the passage until disconfirming information is encountered (e.g., he merely buys a newspaper in the station, or merely goes there to meet his mother-in-law).

Besides the usual provisional application of macro-rules with insufficient data, as in the example above, we also have explicit discourse cues to select correct macro-structures. Such clues include titles, initial summaries, and declaration of content/intention. The reader by convention interprets such properties as approximate indications of the global meaning of the discourse. Additional cues are provided by expressions that indicate the relative importance of certain thematic propositions, expressions such as *The crucial point is ...*, *And then the most important thing happened ...*, *But, suddenly, ...*, etc. Such expressions will be called *topic markers*. They are textual warrants for the plausibility of some hypothesis concerning the macro-structural or functional (e.g., narrative) relevance of some proposition. A less subtle focusing device is the use of italic or bold print for particularly important information.

Another cue for production/comprehension strategies consists of the relative length, complexity, or completeness of a certain part of the discourse. Discourse is hardly ever complete; it picks out some relevant facts from among other facts which may be inferred or are irrelevant. This selection procedure enables a speaker to draw attention to certain states, events, or actions by increasing the relative density of representation for some events. In other words, as soon as some complex property or event is judged to be relatively important by the speaker, he will give more details. This is particularly so in natural stories. If I want to describe what happened to me in the train, I may give some details about where I was sitting, what I was doing, who my fellow travelers were, etc., but I would not give the same type of details about the complex action of taking a cab to the station. Our knowledge of discourse strategies of this kind would automatically raise the expectation that something important will happen (the COMPLICATION of the story) as soon as I say "When I went to the ticket counter, and asked for a ticket to Paris . . .".

Finally, there are strategies based on contextual cues and knowledge of the general communication situation. We may know the speaker so well that we may easily predict the main themes of his discourse, even with very scanty informa-

tion. Similarly, we may know the current 'topics of conversation' of a group or a newspaper. Our actual knowledge of the world will enable us to construct the major topics of any discourse about the oil crisis, for example. Familiarity with the relevant macro-structures will certainly facilitate the task of global comprehension. Unusual macro-structures and super-structures which do not correspond to frames possessed by the reader will tend to be distorted into structures which do satisfy his actual frames, or else be quickly fragmented and forgotten.

The strategies for discourse comprehension mentioned above are all rather general. It should be emphasized that individual differences are important in such complex tasks as discourse comprehension and storage and retrieval and in other comprehension-based tasks such as summarizing and question answering. Just as a group or culture may have common 'topics of conversation' frequently expressed in its discourses, an individual will express his own preferences and interests, etc. Thus, if we want to buy a car or we just bought one, we will be more interested in advertisements and articles about cars. These individual differences may also determine the differences in learning from discourse. How differences in knowledge and interests determine discourse comprehension and macro-structure formation is a problem that has not been attacked, either theoretically or experimentally. There are important methodological reasons to first try to assess the more general, conventional strategies involved in discourse comprehension.

MACRO-STRUCTURES IN OTHER COGNITIVE DOMAINS: SOME FINAL REMARKS

The principles of macro-processing are not limited to discourse comprehension, but characterize complex cognitive tasks in general. We will assume that such activities as thinking, problem solving, social interaction, and visual perception are governed by similar rules and strategies for complex information processing as those operating in discourse production and comprehension. The basic idea in all these cognitive domains is that large and highly complex amounts of information must be organized and reduced in appropriate ways, without which processing (storage, control, retrieval) would be impossible. Although our Long Term Semantic Memory has a very large propositional capacity, this does not mean that it can or needs to store the large amounts of detailed information processed by Short Term Memory and Episodic Memory, although it cannot be denied that we know many loose facts' that are not systematically related to our general world knowledge. The degree of relatedness of particular facts in LTM depends on the frequency with which these facts occur as premises in inference processes. In this sense the particular fact that World War II started in 1939/1940 is more relevant than the particular fact that there are 50 books on the topmost shelf of the bookcase in my office.

In visual perception, macro-rules may be formulated to account for our ability to interpret, store, and recognize the 'relevant' information from a great number of pictures or complex scenes. Processes of generalization, deletion, selection, and construction may be formulated as underlying principles of 'schematic' visual comprehension. Conventional and other general knowledge (frames) of objects, properties, and events would play a role similar to that sketched for discourse comprehension.

Similarly, the planning, execution, and control of an action^s may be made explicit in terms of macro-processing. For example, 'macro-actions' may be represented as plans within the framework of a global purpose, representing the global goal. Inverse application of macro-rules then allows the execution of subordinate preparatory, component, and consequent acts at the local level under the scope of the macro-structural plan. For instance, if I plan to go to Paris with the purpose of visiting my aunt, my global intention does not include the intention to sit on a particular seat in the train. However, the sequence of detailed actions is ordered and controlled by the macro-structure of the course of action. More generally, we will decide to do a_1, a_2, \dots, a_n , only if we know that we will thereby execute the global action A , and if we know that B is a probable or necessary consequence of A , and if B is a necessary condition for C , which is our goal.

We have not provided the details to substantiate the speculative remarks of this final section. Our intention is merely to suggest that the notions of macro-structure and macro-rule in discourse processing may be special cases of more general cognitive principles underlying higher-order processing.

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^sFor an introduction into the theory and logic of action, see van Dijk (1977) and references given there. The analytic notions of conditions, components, and consequences (of action) used in this paper in relation to macro-structures and frames are elucidated there. At the same time, the theory of action and action description provides a basis for narrative theory and yields predictions about macro-processing of stories (see van Dijk, 1976a, 1976b).

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