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### Discourse meaning and memory

#### : Review article of Walter Kintsch, *the representation of meaning in memory*

Teun A. Van Dijk<sup>a</sup>

<sup>a</sup> University of Amsterdam,

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**DISCOURSE MEANING AND MEMORY\***  
**REVIEW ARTICLE OF WALTER KINTSCH, *THE***  
***REPRESENTATION OF MEANING IN MEMORY***

Teun A. Van Dijk  
*University of Amsterdam*

1. INTRODUCTION

1.1. In his new book Walter Kintsch has collected a series of theoretical and experimental papers on the structure and processing of meaning. He mainly studies the propositional structures of discourse and their role in the representation of knowledge in memory, and in the processes of comprehension, inference and recall. The experiments reported have been carried out in the department of psychology of the University of Colorado at Boulder, in part with the collaboration of colleagues and students (Edward J. Crothers, Gregory Glass, Janice M. Keenan, Gail McKoon and Dorothy Monk). The theoretical framework developed in *The Representation of Meaning in Memory* (henceforth: RMM), presented in the first part of the book, is a further elaboration of Kintsch's work on semantic memory (Kintsch, 1972) and of the ideas on conceptual processes formulated in his earlier book *Learning, Memory and Conceptual Processes* (1970). The difference with earlier work, however, appears most clearly in the sophistication of the theory and in the extension of the empirical domain to the *semantic structures* and processes underlying *complex sentences, paragraphs* and *discourse*. In agreement with the more general tendency in actual cognitive psychology and artificial intelligence, Kintsch draws upon recent developments in logically and semantically based linguistic theories, e.g. generative semantics, case grammar and text grammar. Within psychology itself RMM should be placed in the perspective of various recent attempts to provide the first elements of a theoretically sound explication of important pre-behavioristic ideas about memory and recall, especially those of Bartlett (1932). In particular it is demonstrated, in line with current psycholinguistics, that memory and recall of sentences and discourse is essentially semantic, and that the representation of meaning in memory should be given in terms of propositional structures and inferences.

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1.2. This review-article of Kintsch's book will focus on the main theoretical proposals and on experimental results insofar as they are connected with the theory and provide insight into the basic properties of discourse processing. It is written from the point of view of a linguist, so particular attention will be paid to the application of linguistic models. In this case we will have to discuss not only the relevance (and limitations) of linguistic theories for cognitive models of language processing, but also the importance of theoretical and experimental results in cognitive psychology for the elaboration of empirically adequate grammars. A more general discussion about the methodological distinction between competence and performance, or between grammar and cognitive models, will not be given. In the light of important results both in psycholinguistics and in sociolinguistics, such distinctions, at least as they were intended by Chomsky, have lost much of their usefulness.

It will be concluded from our analysis of RMM that it is a very important book both in psychology and in linguistics. No book, of course, is perfect, and since a review is not the same type of discourse as an eulogy, we will have to formulate a number of questions, objections or criticisms. In part these pertain to the use of formal models from linguistics, although in that case the criticism often is addressed to the linguistic models themselves. At the time Kintsch was writing most of the papers collected here, a number of theoretical insights had simply not yet been published. We are also aware of the fact that the aims of grammar and logic are different from those of cognitive models. More particularly, the explicitness and completeness we require of grammatical descriptions is often fully impracticable for psychological experiments, especially with materials of great length. To give a formally adequate propositional description (in some formal language) of some hundred free recall protocols of several pages, is of course far beyond serious consideration without computerized analysis—which at the moment is impossible.

Other limitations of the book have been intentional. Kintsch does not attempt to provide a full and explicit processing model, therefore precise experimental predictions are impossible. As far as we can judge, such an explicit processing model would be premature, in the same sense as no linguist in his right mind would claim to provide a full grammar. We have to work, in both domains, on important problems, such that the basic properties of language and language processing can be accounted for in systematically successive steps. All other processing models now available which claim to be fully explicit, e.g. Anderson & Bower's HAM, are inadequate for important theoretical and empirical reasons: they do not account for language (re-)production, reconstruction, inductive inference, recall, summaries, and so forth, i.e. for most crucial linguistic abilities in which information is transformed in some way.

1.3. In some cases our comments will contain tentative proposals for a different account, based upon our own work in text grammar and logic and their

cognitive basis.<sup>a</sup> These suggestions do not only pertain to linear structures of discourse, but also to global, over-all structures (macro-structures) of discourse and rules for complex information processing. In recent papers Kintsch has adopted a similar line of research, as a natural extension of his results in RMM.<sup>b</sup>

## 2. THE METHODOLOGICAL AND THEORETICAL FRAMEWORK

2.1. One of the first methodological starting points of Kintsch is his emphasis on the importance of *linguistic and logical models* in cognitive psychology. The advantage of such a strategy is clearly that in this case we at least also buy the explicitness of such models, which enables us to make the necessary empirical predictions. For a linguist it is surprising to discover that the same formal representations of sentences he is familiar with re-appear in the description of knowledge and memory stores in cognitive models. In many other cognitive models graph-theoretical representations are used, whereas Kintsch uses the more practical propositional format, which is formally equivalent. One of the obvious reasons for this similarity of cognitive and linguistic (logical) representations could be the hypothesis that what we store in memory is basically the meaning of words, sentences and discourses, and that the linguistic models precisely try to make explicit this meaning. Similarly for logic which, at least traditionally, was intended as an idealized and highly abstract representation of intuitively valid modes of reasoning. For a certain number of utterly simple processes of inference, actual logical models may therefore be part of cognitive models. Kintsch, who rightly wants to stay close to concrete proposals, does not discuss this sort of motivation for his use of linguistic and logical models. Instead of slavishly following new trends and insights, he emphasizes classical and more recent psychological work, e.g. on memory for word lists. He shows that some of the results of those experiments can be generalized even to properties of discourse, memory and recall.

2.2. A certain number of classical linguistic and psychological distinctions are questioned by Kintsch. First of all, he correctly criticizes the *competence-performance* distinction, and claims that grammars which do not take into account

<sup>a</sup>This work should be placed in the framework of some recent developments in linguistics under the label 'text grammar'. For extensive references, see van Dijk (1972), Petöfi & Rieser (eds.) (1973), Dressler & Schmidt (1973). For the (predicate) logical aspects of linear structure of texts mentioned by Kintsch and referred to in this review, see van Dijk (1973) although a number of important corrections—e.g. treatment of linear coherence in terms of a formal semantics, and treatment of natural connectives—are necessary in that paper. For a recent collection of descriptive applications of fragments of text grammars, see van Dijk & Petöfi (eds.) (1975). For cognitive implications, see van Dijk *et al.* (1975).

<sup>b</sup>See e.g. Kintsch (1975) and Kintsch & van Dijk (1975) in which attempts are made to find experimental confirmation about grammatical, logical and narrative theoretical hypothesis about the processing (recall, summarizing) of complex discourse, e.g. stories.

psychological properties of memory are probably not very relevant in linguistics either. As such, this claim would probably be accepted by any generative linguist in the Chomskyan paradigm, who wants to reconstruct an idealized system of cognitive abilities. The problem is, as has been made clear by Bever (1970), that the only evidence we have is factual language use, because our expressed intuitions about grammaticalness are merely a very specific part of our linguistic abilities. More important still is the fact that a number of grammatical structures have their direct basis on more general cognitive structures. Hence the distinction between grammatical rules and cognitive processes is blurred. It seems more relevant to distinguish, therefore, between *rules* and the ways or *strategies* in which they are used in most effective comprehension and communication.

Less convincing are the arguments which have led Kintsch to assume that there is no distinction between *structure* and *process* in cognitive models. Since structures are not 'fixed', and have no existence of their own, but are generated in a different way in different contexts, they cannot properly be distinguished from those processes of generation (where 'generation' is meant in the non-technical sense). It seems to us that, even if different structures are operated on, and result from, rules and processes, the distinction between operations and the structures operated on, is methodologically necessary both in grammar and in psychological or artificial intelligence models. A proposition is simply not identical with the rule or process of inference based on it, no more than a computer program is identical with its data base.

2.3. RMM adopts the distinction, made by Tulving, between *episodic* and *semantic memory*, where the former records personal experiences in a given context, and the latter the more abstract generalizations of knowledge. Whereas most traditional work on verbal learning focused on episodic memory (for material presented in a specific task in a specific experimental context), recent work has more interest for the knowledge upon which our cognitive processes are based and with which semantic structures of input are connected.

The *acquisition of knowledge*, indeed, is of central importance in learning theory and, it should be added, in social psychology. Kintsch stresses the first aspect, as most cognitive psychologists do. However, language is not merely devised to express thoughts, but also as a means for communicating them in processes of interaction. In this respect knowledge and memory, and the very notions of rule and convention, are essentially social. Without common knowledge and beliefs *communicative interaction* is impossible. This is not merely a trivial fact from social psychology and socio-linguistics, it has its direct bearings on a serious theory of discourse structure.

The notion of episodic memory is crucial in a serious explication of recognition behavior: its contents are defined by properties of particular information and by circumstances of the input events. The problem is that we have no explicit way in which we make a distinction with semantic memory as intended by

Tulving and Kintsch. More in particular, we do not know which episodic information, and under what precise conditions, is erased from episodic memory, and which information is integrated into our semantic stores. A formulation of these conditions and rules (processes) is a primary task in an account of knowledge acquisition.

It is not usual in actual psychology, and neither in RMM, to make a distinction between different sorts of semantic memory. It seems useful to distinguish at least between a store or phase in which (representations of) *particular facts* are stored (e.g. 'that Peter is bald') and a store in which inductively or deductively acquired *general facts* are stored. Among these general facts we have the usual meaning postulates, the rules and conventions which determine inferential processes on the one hand, and the general synthetic information on which these inferences are based (e.g. 'Trees get new leaves in spring'). Finally, RMM avoids the problematic question of the cognitive format of *ideas* by identifying them with propositions. Kintsch does not exclude pre-propositional ideas *a priori*, but stresses that, first, we do not know anything about them and, second, we have models available to account for propositions. This is a sound decision. Even if we would know something about pre-propositional ideas, we would have to describe them in some theoretical language, which again would require propositions. Brute ideas and brute facts of the world may well exist, but they become theoretically relevant only when they are perceptually or linguistically interpreted, i.e. translated into some language. In other words, ideas interest us only in so far as they are somehow expressed.

Similar remarks may be made on the role of *images*, a problem popping up regularly in RMM. It seems very implausible that an image is based on propositions, as Kintsch assumes (p. 6). The amount of visual information we may process in a few seconds is much greater than a similar amount of propositional information. This implies that our visual memory is much more powerful: we simply do not remember a face by description (which indeed would be very long) but by checking our visual episodic memory. Nevertheless, visual memory and propositional memory are intimately related: we can describe what we see or have seen. Again, processes of selection and interpretation are involved. Images are not propositional, but our interpretation of images as used for certain tasks (inference, description, etc.).

The problem of the existence of non-propositional information is also relevant in other cognitive domains, e.g. in action and the planning of action. A serious theory of action includes a 'mental' component, specifying the preferences, wishes, purposes and intentions of actions. The same holds for practical inferences (If such and such is that case, DO so and so). These are again described in propositional terms. How actions are 'really' programmed and controlled does not seem interesting as long as we cannot talk about it. This does not mean that, while eating a sandwich I permanently repeat a proposition as 'I am eating a sandwich' or

'Now I will take another bite', although in consciously planning my actions I very well may formulate proposition-like structures (e.g. 'When the weather is so bad, I better take the train'). Hence, just as our thinking is closely related with our language, our experimental and theoretical insight into certain phenomena cannot be taken independently of our theoretical and descriptive languages.

### 3. PROPOSITIONAL STRUCTURES

3.1. The representation of meaning in RMM, as we saw, is given in terms of *propositions*. A proposition is specified in terms of *concepts*, represented here by their natural language expressions (in upper case letters). The set of concepts is a subset of semantic memory. Semantic memory, and hence the set of concepts, is personal, although the general properties of our semantic knowledge are culturally shared with others. It is stressed that the representations involved have a psychological character, and are not intended to be philosophically adequate.

The latter position, however, seems problematic. It is clear that there are practical reasons not to adopt the explicitness and the distinctions of philosophy and logic when propositional descriptions are used in psychological experiments or process models. However, most formal properties introduced in theories of logic have an intuitive, linguistic basis: they are relevant to account for structures of sentences and for structures of inference. In that respect they are also psychologically relevant.

A difference is made in RMM, as well as in some other recent work on semantic memory, between concept *tokens* and concept *types*, where the former denotes the use of concepts in the description of other concepts. This distinction—if it is relevant at all—is different from the usual distinction between *type* and *token* in linguistics and logic. There a token is defined as a spatio-temporally unique occurrence of a (realization or manifestation of a) type. In semantic memory we do not seem to have this or the other distinction. A 'definition' or 'description' of a concept is not given in another language or at another level, but specifies relations between concept types. A distinction becomes relevant only in our use of semantic, conceptual knowledge in object language or meta-language respectively.

3.2. The propositional format, according to RMM, can be used to represent both *concepts* and whole *discourses*. Of course, such a claim requires qualification. Texts are not simply sets or sequences of concepts, nor are text structures identical with conceptual structures. A formal semantics is necessary to make the differences explicit. A concept is a function, taking values in (sets of) possible worlds: the individuals. Propositions, however, are interpreted as truth values or facts in some particular possible world or context. Discourse, taken as a sequence of sentences related with a sequence of 'underlying' propositions, may describe properties of some specific world (or a time sequence) which cannot merely be given by concepts. Hence, understanding a discourse not only requires an understanding of its concepts, but also of the relations between concepts in a proposition, and of the

relations between propositions in a sequence. This ‘understanding’ has at least two dimensions, viz. the assignment of a (conceptual or intensional) meaning structure, and the assignment of a referential or extensional structure (individuals, properties, relations, time, space). The first interpretation determines whether a sentence or text is ‘significant’, the second interpretation (which is a function of the first) determines whether a sentence or text is true, refers to something, etc. This second type of (referential) interpretation, as made explicit in logical semantics, is neglected in much work on linguistic semantics, and does not appear in RMM, although it is crucial to define the structure of discourse.

3.3. The sequence of propositions underlying a discourse is called a *text-base* in RMM. A text-base is intuitively interpreted as a full ‘expression’ of the ideas of a speaker. During mapping into morphological and syntactic surface structures (which are not discussed in RMM) some propositions of a text-base may be deleted such that surface structure may be ambiguous, whereas the text-base itself is explicit and hence non-ambiguous. We will see below that the text-bases used in RMM do not have this fully explicit nature, and should be considered as base structures which are closer to the actual sequence of clauses and sentences.

A *proposition* is defined in terms of *predicators* and n-tuples of *arguments*, in the usual way. The notation used in RMM is non-standard: the predicator is written as the first term of an n-tuple. Word-concept expressions are used both in predicate and in argument positions. We here meet a number of difficulties involving differences between natural and formal languages. It is usual to take natural language concepts as predicates in a predicate logical syntax, whether they are verbs or nouns in surface structure. The argument places in that case are occupied by (bound) variables ( $x, y, \dots$ ) or by constants ( $a, b, \dots$ ), ‘over’ which the predicates range. It must be borne in mind therefore that the argument-concepts in the notation of RMM at the same time identify and qualify individuals, whereas the predicates assign properties or relations. These important formal differences are not sufficiently clear in RMM.

Propositions are related by *connectors*, determining the linear ordering of the text base. Connectors are also taken as predicates, viz. as relations between propositions. Although in logic connectives are normally taken as binary constants or operators (making propositions out of propositions), natural language connectives might indeed be taken as predicates of some specific sort, establishing relations between the denotation of propositions, i.e. between facts. In that case, however, they no longer have their normal logical properties, e.g. of associativity. That is,  $p \ \& \ q \ \& \ r$  should be taken as  $(p \ \& \ q) \ \& \ r$  or as  $p \ \& \ (q \ \& \ r)$ . Propositions may be expressed by various (equivalent) surface forms, depending on pragmatic context. Assuming that this is indeed the case, i.e. that the ‘same content’ may be expressed in various, e.g. stylistically different, ways, we would still want to integrate into the propositional text base a number of elements which in RMM are supposed to be provided by pragmatic rules (which are not given). One example are informations about time, tense and aspect. It may be maintained that *John smokes pot* and *John*

*is smoking pot* have different meanings, to be represented with different propositions.

3.4. Since a text-base is defined as a sequence of propositions, it must be made explicit what sorts of orderings and connections are involved, and what conditions determine the intuitive notion of *coherence* of a text.

One of the basic properties of textual coherence at this (linear) level is certainly *referential identity*, i.e. the property of terms referring to the same individual. RMM mentions this condition, but there are some difficulties involved due to the natural language notations used. In a logical language we simply use identical constants to refer to the same individual. However, unlike the 'words' of natural language, these constants do not at the same time characterize the individual. That is, I may refer to the same individual by using the term MAN but also by using COLLEAGUE, HUSBAND, etc. Hence, the identity of terms, as in RMM, is neither necessary nor sufficient to establish referential identity. In order to avoid this difficulty for different referents with the same 'name' RMM uses, much like original generative syntax, different subscripts, which in fact is a way to introduce individual constants.

Referential identity is one of the primary properties of linear coherence of text-bases. It should be stressed, however, that it is neither sufficient nor necessary. In terms of RMM we may also relate propositions with a connective like BECAUSE without the identity of predicates or arguments ('It is so hot, so I go to the beach'). From this example we may already see that connectedness of propositions should indeed be determined at the level of reference, but not (only) as an identity or continuity of individuals but as a certain relation between *facts*. This is nearly trivial when we realize that, as we assumed above, facts are the denotation of propositions. A causal relation is one (rather strong) type of these conditions of relatedness between facts. More in general we assume that two facts are related if one of them is a condition and/or a consequence of the other, varying according to strictness (from possibility/compatibility to logical, physical or other types of necessity).

At the time Kintsch wrote his papers the majority of work in sentence and text grammars, however, was concerned with referential identity, and the semantic condition underlying such important grammatical rules as those of pronominalization.

3.5. RMM makes an interesting attempt to go beyond the linear connectedness of the text-base, in order to account for the obvious *hierarchical* relations between propositions. Such attempts have been made before, including in classical grammar, in order to account for sentence structure (coordinate and subordinate clauses). Recently, following Grimes (1972), Meyer (1974, 1975) has given a rather full account of such 'rhetorical' relations between sentences/propositions. Although there is no question of a serious theory in all these cases, the approaches are very important. One of the crucial implications of such a hierarchical description of text-bases would lie at the level of processing (comprehension and

storage) of discourse: a hierarchical structure is much easier to decode and store than a non-structured linear array.

The rule formulated in RMM, however, is not fully clear nor motivated: why should a proposition be 'subordinated' to another proposition if one of its terms (i.e. word-concepts) occurred in this other, previous proposition? Neither syntactically nor semantically does this rule seem satisfactory. Take, e.g., the sentence *John came in and (he) kissed Mary*, of which the clauses are coordinated, whereas the two clauses function both as assertions, of which perhaps the second one even seems the most important of the whole message. The only sense in which the second proposition might be 'dependent' would be the fact that its presuppositions are entailed by the first proposition ('John exists' or 'John is in the room'). In other words, the formal interpretation of the second proposition must be given in a possible world which is specified by the first proposition. This notion of (con-)textually *relative interpretation* is one of the specific aspects of the semantics of discourse, but 'hierarchy' is not yet achieved by it.

RMM briefly discusses *macro-structures* of discourse, i.e. structures characterizing a discourse as a whole. Again, this is a fundamental way to specify the *specific* nature of discourse, as well as a basis for an explanation of the cognitive processing of discourse. In RMM, a list of propositions may receive a 'name', e.g. the *Introduction* of a story, psychological article or speech. These names may again be ordered, and again be dominated by a higher level name. This seems a first step in the right direction. Since all meaning in RMM is propositionally expressed, however, one would expect rather a structure in which higher order 'names' would themselves be propositions. In that case we could formulate mapping rules from sequences of propositions onto sequences of propositions, where the latter could be viewed as 'summarizing' the former. This proposal has been elaborated in more recent work on these problems, also by Kintsch himself in a number of experiments.<sup>c</sup>

3.6. A semantic memory must contain not only the rules interpreting propositions and text-bases as described above, RMM also pays attention to the interpretation of *metaphorical sentences*. A metaphorical sentence, then, is first extended to an acceptable comparison, in which the property in question (*tertium comparationis*) is expressed; a second transformation then deletes both the 'literal' elements. This is a very classical account which, however, has been reformulated in other terms in generative grammatical treatments. Two brief remarks are necessary. First, a sentence may be assigned a metaphorical interpretation without being semantically unacceptable, nor can each unacceptable sentence be assigned a metaphorical interpretation in each context. A certain number of semantic relations between concepts must be satisfied: arbitrarily selected concepts do not make metaphorical sentences in most cases.

Second, the metaphorical interpretation of a sentence depends on text and

<sup>c</sup>See note b.

context. In order to decide whether e.g. it is the predicate or the argument (or rather the verb or the noun(s)) which are to be taken metaphorically, we have to inspect the context in order to establish the referents or topic of the discourse.<sup>d</sup>

3.7. Chapter 3 of RMM further specifies the *propositional structure* of the text base in order to provide a more adequate account of meaning structures. A number of important topics (definite and indefinite description, quantification, modality, implication and presupposition, time and tense) are discussed. It is clear that such a treatment cannot be complete and only may mention the main properties of these phenomena. In the same way, it is not possible here to discuss RMM's exposition of the topics in detail, to propose corrections or add necessary information about recent developments in logical grammars. A few remarks will have to do. As we have mentioned above, referential identity has only indirect relations with repeated nouns. The same holds for *definite articles*, which are used if the speaker assumes that the hearer has identified a specific individual, either by the previous part of the text, or by context (general or particular knowledge). This means that we may use a new noun in a discourse with a definite article only if it refers to an identified individual. This is the rough rule; there are a number of refinements, which need not be discussed here. In all other cases we have an indefinite noun phrase.

The distinction *particular-non-particular* is known in linguistics but has not been tried to explicate in logic. Pragmatic rules are involved, e.g. whether the speaker finds it necessary to further identify some individual spoken about. Individuals may well be particular even if they are not further identified in the text base, as is assumed in RMM. As far as we know, there is still little insight into these matters of particularization and its relation with identification, qualification, determination, and related concepts.

Similar questions may be asked about *quantification* in natural language. For reasons of simplicity, RMM takes quantifiers as predicates, but there the demands of practicability probably will lead to trouble. Quantifiers have rather different semantic and logical functions from predicates (verbs, adverbs, adjectives, and—although not in RMM—nouns). Quantifiers select from some universe of discourse or, in a given text, from a set of individuals already introduced, a number of individuals to which a predicate is assigned. This selection is purely 'numerical'. Predicates may also select individuals for further predication ('The blue ones were my favorites'), but in that case they merely characterize a certain (sub-)set.

Under the notion of *modality* many different notions are usually treated, not only the 'real' modal clauses or adverbs like 'It is possible that . . .', 'Perhaps', etc., but also negation, sentence adverbials of other kinds and propositional attitudes ('X believes that p').

RMM uses constants for propositions to which a predicate is assigned such that a propositional adverb can be generated. This is correct for sentential adverbs,

<sup>d</sup>For some of the points raised here, see van Dijk (1975) and the references given there.

but adverbs may also apply to just one ‘term’ of a sentence: ‘Unfortunately, Mary gave him an apple’ (and not e.g. a pear). In that case, the adverb only applies to ‘apple’, and hence we need a notation separating the presuppositional and the assertional part of the sentence, e.g. <GIVE (MARY, *a*, *b*)> & UNFORTUNATE (APPLE (*b*)). Such a notation again requires a distinction between constants for individuals and concepts for properties and relations, as noticed above.

As noted in RMM, there is indeed a systematic relation between (logical) *modalities and quantifiers*. In the semantics for e.g. ‘It is possible that *p*’ we specify that *p* be true in ‘at least one’ possible world. Only in some cases such a relation also appears in surface structure of sentences. In general, however, we may not simply consider sentences like ‘Some bears bite’ equivalent with ‘It is possible that bears bite’. The first sentence implies that at least one bear bites, which is not implied by the second sentence, which merely states that in some circumstance (any) bears bite, a circumstance which need not become realized. RMM correctly stresses that *implication* and *presupposition* cannot simply be defined in terms of the material conditional. Notions of semantic and conceptual relations between propositions are involved, not merely truth values. Establishing a distinction between lexical and textual presuppositions, RMM does not consider textual ‘presuppositions’ as real presuppositions. This conclusion, however, is based on an erroneous interpretation of the notion of a presuppositional relation. Of course, the sentence ‘Mary found a puppy’ is not presupposed by ‘Mary loves the puppy’, but it is presupposed by the *complex* sentence ‘Mary loves the puppy she found’.

*Time and tense* are notoriously difficult topics in logical grammar. Sometimes, time expressions are used as arguments. RMM again uses predicates over propositions, which is acceptable if we use ‘minimal’ propositions as indicated above. A sentence like ‘I saw the dog in the garden’ is three times ambiguous: I may be in the garden (and see the dog there or somewhere else), the dog may be in the garden (and I may be in the house), and both the dog and I (and hence the event of seeing) may be in the garden. These differences must be expressed by different underlying propositions. In this section Kintsch gives an interesting discussion of some *cognitive properties of tense and time*, for example of the ‘now-consciousness’ defining the present tense. Although little preliminary work is available, a similar cognitive interpretation of other propositional structures and categories would have been desirable as a sound basis for a logical grammar.

RMM sometimes mentions pragmatic constraints determining surface structure. This is particularly the case for tense, where the moment of utterance is the ‘starting point’ for all tenses with respect to which the time of the event(s) referred to, as well as the focus on certain events, is determined.

3.8. These few remarks will have to conclude the discussion of the framework used in RMM for the representation of propositions and text-bases. Although a certain number of corrections and additions seem necessary, the framework as a whole is a good starting point to account for the representation of meaning in semantic memory. It allows for the operation of the necessary inference

rules, and the application of other logical properties. Moreover, Kintsch has not merely adopted a linguistic formalism, but also drawn consequences for cognitive implications. The rest of the book provides extensive theoretical and experimental support for his model in the account of discourse processing.

#### 4. A MODEL OF (LINEAR) DISCOURSE PROCESSING

4.1. Most important for psychology is of course the process model operating on the structures as described in the first chapters of RMM. The process model will have to describe how propositions are actually understood, how they are combined and organized in the different semantic stores, how the new information is combined with the system of knowledge already stored, and how the stored information is retrieved for such tasks as recall, recognition, question answering, problem solving, summarizing and, last but not least, (task-independent) production in general. Although we are far from competent to judge about Kintsch's proposals, we will briefly summarize them and add some provisional comments.

4.2. At the end of Chapter 3, Kintsch had already given his basic philosophy, by criticizing the associationist tradition and especially the pseudo-associationist framework of Anderson & Bower (1973). He correctly emphasizes that a sound process model must also account for *productive processes*, and that the vague notion of 'association' should be made explicit in terms of definable relations. Referring to early work by Selz, four basic *processing operations* are mentioned: pattern completion, pattern matching, abstraction/differentiation and generation.

In chapter 4, further specialization is given of these operations, especially in the perspective of classical results of list-learning experiments.

*Recall* is systematically distinguished from *recognition*. The first process requires organization of input material, whereas recognition can only be enhanced by more study trials in which the trace of some target item is confirmed. Recall, however, presupposes recognition in the two-stage model of RMM: information is first retrieved from semantic memory and then checked with the information available in episodic memory. The use of sentence material, which is nearly always 'new', excludes any sort of 'tag'-model, in which old information units are tagged. During comprehension the same word may be represented in different ways in different sentential structures. This is also the reason why the properties of list learning cannot simply be generalized for sentence or discourse processing.

Processing is based on a *semantic memory* of which a lexical memory is a subset. Lexical units are characterized by morphonological, syntactic and conceptual information as well as sensori-motor information.

The processing itself essentially consists of *pattern matching* and *pattern completion* operations. The likelihood of a match in pattern completion depends on the number of (lexical) elements two units have in common.

Although it is indicated that this quantitative condition is not the only one, it

might be the case that it is even of secondary importance. Take for example the following inputs:

- (1) / s t r a w b /  
 (2) / s r w e r y /

of which the number of elements (graphemes) are identical and which share the same number of elements with the lexical unit *strawberry*. It is clear, however, that the probability of correct completion for (1) is much higher. Hence, further constraints are necessary, especially those pertaining to the structure of the input.

RMM extends traditional *short term memory* (which is primarily phonetic and serves for the identification of morphemes) to a broader conception of STM which recalls James' *primary memory*. In this STM, elements are kept in store until they have been fully interpreted, e.g. in case of ambiguous expressions or sentences, which requires the presence of other lexical items in context. After interpretation the items disappear in sub-conscious episodic memory.

A number of questions arise in such an account, even if it only was intended as a global and provisional framework:

—which elements, or which parts of lexical units are kept in store (also the phonetic representation?), how many are kept in store, how long, and above all, which ones, and why?

—how can disambiguation or further interpretation be related with visual input?

4.3. RMM correctly emphasizes that processes of *recall* require previous organization of the input material. Memory elements  $M_a, M_b, M_c$ , etc. can only be accessed if there is an element  $M_j$  such that  $M_j$  is systematically related with  $M_a, M_b, M_c, \dots$ . This relation may be one of set membership, part-whole relations, or likely or conventional case relations. The difficulty of rote-learning is due to the absence of such systematic relations ordering the input in classes/categories and higher order structures (propositions). For any input of sentential dimensions and longer, pure rote learning is therefore impossible under normal circumstances.

Cued recall is often a form of *recognition* if the cue has been encoded together with the target word. Probably the same would hold for lexical equivalent words as cues, because phonological structures do not even enter the (longer) STM. False recognition is a function of the similarity measure of the distractor. This similarity measure, as we said above, must however be specified in exact structural terms: where 'typewriter' may do fine, 'retirwepyt' would probably fail, although it has the same phonemes and the same (inverse) order. Response latencies in recognition are a function of familiarity. Familiarity is defined in terms of common elements between test word and memory trace. This seems acceptable, but one would expect that identification and counting of more (similar) elements would take more time, and hence influence response the other way round.

4.4. Although the general processing framework may be acceptable for language processing beyond list learning, it is obvious that sentence learning has a number of very different properties. Whereas words can be matched with lexical units in memory, sentences are not available as such, and therefore should be constructed by rules. In particular, morpho-syntactic surface structures of sentences, as will be concluded from the experiments reported, vanishes after some minutes from episodic memory, leaving only a propositional trace. Hence, recognition of sentences is only possible in immediate tasks. Precise surface recall depends on the length and the structural complexity of the sentence. Since such recall tasks are unnatural, training would be necessary to enhance the relevant abilities. Under specific conditions, propositions may be 'recalled' which are implied by the input propositions of a discourse. The most important question for the recall of discourse is to find the semantic 'cues' which guide the search for stored propositions. In other words, we must know how discourse information is stored. According to Kintsch's own suggestions about hierarchical linear and macro-structural relations between propositions, these higher level categories and 'names' (concepts or propositions) may serve as such search cues. This hypothesis is not formulated directly in RMM nor specifically tested. Most experiments deal with the semantic structure of complex sentences and paragraphs at the linear level.

Kintsch is aware of the fact that at the moment we are unable to provide a detailed processing model for more complex linguistic information processing. We simply lack the relevant experimental data. The theoretical distinctions made in RMM seem plausible, but a much more detailed framework is necessary to be able to answer some of the questions asked above. The experiments carried out by Kintsch and his associates provide valuable suggestions for such a framework.

## 5. THE EXPERIMENTS

5.1. Even less than about the processing model can be said about the experiments. As a linguist without experimental training one cannot be but impressed by the ingenious experimental designs of Kintsch, and critical remarks are out of place in such a case. Kintsch is in general very cautious with the interpretation of his experimental results: he does not want to force them in order to fit the theoretical framework, so that inconsistent findings are possible. This is natural in an experimental context of which we can only control a limited number of variables, as is always the case with complex meaningful material.

The experiments all deal with *semantic processing*: the nature of the underlying entities, their relations with surface structure, the basis of inferences, etc., often tested with the usual reading and response time procedures, yes/no or true/false questions, and so forth.

5.2. The first result obtained in the experiments of Chapter 5 is that what is

stored of a paragraph is indeed the propositional structure, independent of the complexity of syntactic surface structure. Of course, syntactically complex sentences take longer to decode, and hence restricted reading time will impair correct interpretation, but once interpreted and stored the information from complex and from simple sentences is equally well accessible when inferences are to be drawn. These inferences are drawn during the task, and not during reading. Another important (negative) finding was that information from longer texts does not take longer time to be accessed than information from shorter texts. This last result is difficult to interpret because one would expect that the search among more propositions would take longer. Probably, the result will not hold in general for any input text. The more complex the text, and the 'lower' the position of some proposition in its hierarchy, the more time will it probably take to retrieve it.

5.3. The experiments of the next chapter demonstrate that reading time/comprehension of sentences are a linear function of the number of propositions underlying the sentences (given sentences of equal length). Clearly, it must be assumed in such experiments that the sentences are also equally difficult, a parameter which cannot yet be explicitly controlled. Every proposition requires approx. 1 second of additional reading time, but the longer the paragraph the longer the reading time of each proposition. In that case it is assumed that the number of relations to be established with previous propositions is increasing.

Whereas the other results of these experiments are straightforward, this last finding is not easily explained. There are theoretical and intuitive reasons why the reading of subsequent sentences will not be a steadily increasing function of the number of preceding sentences, otherwise we would read the last page of a novel in a time enormously longer than the first page, which is obviously false. Furthermore, in reading the first propositions of a text, we still must establish what the referents, the topic or probable global structure and intentions are of the text. This will also take extra time, which is diminished for later propositions. Finally, it followed from the experiments in chapter 5 that inferences from longer texts take the same time as inferences from shorter texts (a result which will not hold in general, as we said). If that is true, the inferences drawn from previous sentences, necessary to interpret a given sentence, will take roughly the same time. It seems likely therefore that reading time will occasionally increase, but not above a certain value, and that the main parameter is the number of relations to be established with previous sentences, as well as syntactic and semantic complexity.

5.4. The experiments in chapter 7 first establish that superordinate propositions are better recalled than subordinate propositions, and that propositions with fewer 'descendants' are less well recalled than propositions with more 'descendants'.

Similar results have been obtained by Meyer (1974). The problem is that an explanation of this kind requires an explicit theory of the hierarchical structure of a text base. We have seen that the notions of 'superordinate' and 'subordinate' in RMM are not well founded. We therefore must look for another interpretation

of the result. A superordinate proposition in RMM is a proposition introducing discourse referents. It follows that such a proposition entails an important presupposition of the subsequent sentences. Hence, whatever proposition is recalled, it requires the presence of the presupposition and hence, indirectly the presence of the 'first' (superordinate) proposition. This provisional explanation at the same time accounts for the 'number of descendants' variable: the greater the number of propositions sharing a presupposition, the more important the presupposition for the coherence of the text. Although such a rule is rather a reading/interpretation strategy, it does not seem a formal rule. We may, in interpretation, construct propositions which dominate a whole sequence of propositions but which do not themselves occur in the text.

That the proposition is one theoretical and cognitive unit is demonstrated in an experiment where the same number of words were related with one or more underlying propositions. Recall for a sentence expressing one proposition was better, whereas recall became partial as soon as more propositions were underlying it.

Recall of propositions is further a function of the internal ordering of the arguments in a so-called *case frame*, i.e. whether an argument was Agent, Object, or Goal. It was found that Time and Place should not be included as arguments in such a case frame, because sentences with time and place expressions behaved like sentences with two underlying propositions, as was predicted by the theory. Less consistent with the theory was the finding that in passive versions of Verb-Agent-Object-Goal sentences the subject/theme is better recalled than the Agent. First of all, if propositions are the base for recall, no differences may result from (syntactic) passive transformations, at least *if* these are purely syntactic and do not affect meaning. As such, the cases of a sentence thus do not affect recall, but only the relationship of an argument term with other propositions of the text, as it is the case for subject/theme, where the argument is presupposed (topic) in the sentence. Often subject/topic coincide with the agent-role, which may explain better recall for Agent-arguments.

The strength of a theory of proposition processing depends on the explicitness of a case grammar semantics. Such a semantics does not yet exist. We do not know, moreover, how many case roles should be included in a proposition, and how many would function as one 'cognitive' unit. Although the theoretical base is still weak, we may subscribe to Kintsch's conclusion that binary models of propositions, like the one of HAM (Anderson & Bower, 1973) are inadequate.

5.5. In the process of mapping a text base on surface structure, propositions may be deleted under specific conditions, viz. if they can be inferred from the pragmatic context, from previous sentences in the text or from the lexical meaning structure of a concept. In order to understand a text, however, a reader must reconstruct the full text-base. It follows that in principle true/false questions about the presence of propositions must be equally correct and fast whether they are actually expressed or implied by the surface structure. This hypothesis is tested in

Chapter 8. It turned out that as such the hypothesis could not be confirmed: questions about implicit propositions took longer to verify, whereas questions about longer paragraphs took longer to answer than questions about shorter paragraphs, a result contradicting the conclusion from a previous experiment.

The experiment used a procedure in which level 1, level 2, and level 3 propositions were distinguished in the text, denoting propositional information about 1 lexical item, 2 lexical items, and textual information, respectively. That a proposition 'A dog is an animal' is not recognized is indeed, as Kintsch observes, a matter of surface constraints. Similarly, for recall experiments, it should be observed that each recall protocol is itself a discourse with its usual rules of discourse, i.e. rules deleting redundant information. Since general meaning postulates are not part of the *specific* content of a text, they will not as such be recognized or reproduced. Moreover, in immediate recall, some memory is left for surface structure. In a second experiment it was found that, once surface structure was erased, after 15 minutes, there was no difference in reaction times for implicit and explicit propositions of second and third level. This is natural for the textual implications of specific information. For these experiments it should be recalled that, besides the output constraints (i.e. the rules observed for the production of a well-formed, non-trivial protocol discourse), the response latencies are a function also of the structural role of a given proposition in the input paragraph. Propositions, whether explicit or inferred, which have a macro-structural role will be accessed directly and hence faster responded to.

The third experiment of this chapter is important for other reasons: it gives insight into the different processing properties of various sorts of discourse. It was found that argumentative discourse reads slower than descriptions of the same length (in words and number of propositions). The same holds for question-answering latencies. In general, explicit questions take longer time than implicit questions immediately after presentation, a difference which disappears after longer delays. The differences are attributed to the greater complexity of arguments and partly to the more abstract character of word-concepts and propositions in arguments. Again, it shows that memory for text is multi-level: surface structure influences recall/answers within short delays. These conclusions are plausible. It should be added, however, that the predictions are not fully based on theoretical characterizations of different discourse types. Similarly, it is obvious that of longer texts LTM does not keep the full set of propositions recorded. We need a short term semantic store ('primary memory') in order to interpret sequences of propositions correctly and thus to monitor conversations and paragraphs. Beyond that level, propositions will be deleted, integrated, abstracted from, and stored in LTM. In that case, the macro-structure of arguments and of descriptions will be constructed along different rules: the same proposition-type may be more important, and hence recalled easier and quicker, for one discourse-type than for the other. This requires a sound theory of discourse types.

5.6. The next two chapters (9 and 10) bring further experimental results

about paragraph processing, in particular about the retrieval of propositional information. In general, longer paragraphs take longer to read (though at decreasing rate), as we saw earlier, and the TRUE-response latencies increase for longer paragraphs (not for FALSE-responses). This increase is bigger for paragraphs than for word-lists. Apparently, as Kintsch correctly suggests, processing at deeper levels takes more time than the surface processing of word lists. Further it was found that verbatim recognition of old sentences is quicker than the processing of new propositions (two words different) in a false recognition task. As soon as the paragraph becomes longer, however, old sentences are recognized less quick. True/false decisions appeared to be different from yes/no decisions, the former requiring the establishment of connections with (con-)textual information, whereas inference times are usually quicker than times to find correct information.

5.7. In order to be able to decide how and how fast subjects judge a sentence to be semantically (un-)acceptable, Kintsch examines a number of proposals for semantic memory, e.g. Quillian's, and concludes that they are in general too simple to account for the facts. Semantic distance of concepts, measured in terms of the number of nodes in a conceptual hierarchy, is not a sufficient criterion for the prediction of decision times for semantic acceptability. It is obvious that definitional sentences which are stored are quicker to judge than sentences which must be first inferred. Memory seems to be organized not only in the most economic and logical way, but also according to criteria of fast accessibility in processing, which makes redundancy possible.

A sentence is said to be semantically acceptable if it could be true in some circumstance. This definition covers only part of the 'significant' sentences: clearly, sentences which do not classically have truth values (imperatives, questions, and so forth) will also be acceptable. Furthermore, the circumstances in which a sentence can be satisfied may very well be non-normal: in general the sentences of science fiction stories will be perfectly accepted. Acceptability, thus, depends on the types of world sets (each with their specific set of basic postulates) in which they are interpreted. It must be kept in mind, therefore, that the experiments carried out, take the 'normality' of the actual world(s) as basic.

It was found that acceptable sentences verify faster than unacceptable ones, especially if subject and predicate are semantically related. Apparently, unacceptable sentences receive an extra check before they are rejected. Following the remarks we made above, this seems to imply that subjects are searching for a possible world (circumstance) in which such a sentence might be satisfied, but that this world is too far from non-normal worlds and hence not admitted as a basis for interpretation/acceptance. Other factors (e.g. imagery) may be involved.

5.8. It was already observed that memory is not necessarily organized in the logically most optimal way: redundancy is possible. This is also the conclusion of the last experiments reported (in Chapter 11) about *lexical decomposition*. This notoriously difficult problem of present linguistics is extensively discussed by Kintsch. He mentions both linguistic and experimental results for and against the

theory that lexical units are stored as sets or structures of features in memory. The question is whether decisions of lexical analysis, which are part of our grammatical competence, are based on (automatic) decomposition or on inferences.

In the first set of experiments it appeared that lexically complex words were not more difficult to process nor took more time to be processed. Initiation, completion, and other tests showed that they were handled just like simple units. The same holds for the amount of information recalled when sentences with simple or complex words were given: no significant differences. When we take a component word as a recall cue, it appeared to be less powerful than a word occurring in the sentence itself. Hence, if required in a task, a word *can* be decomposed, but in general it is processed as a unit.

Kintsch correctly observes that this result has no implication for linguistic theory, which is concerned with the abstract structure and relations of concepts. Indeed, since subjects are sometimes able to analyse concepts, a grammar must provide an account of such an analysis.

## 6. CONCLUSIONS

6.1. Kintsch is reluctant to draw too far-reaching conclusions from his experiments, emphasizing that they were carried out in order to obtain suggestions for a processing model rather than test such a model. Let us briefly summarize his main results:

1. memory is semantic, consisting of a structure of propositions for particular facts/discourses and of a more general system of rules and a *lexicon*;
2. propositions are constructed as predicate-argument structures, where the arguments are ordered in a case-frame;
3. in processing and in memory lexical units (concepts) are not decomposed, but inferences based on meaning postulates can be made in specific tasks;
4. surface structure differences do not influence storage and recall, but only time and difficulty of interpretation;
5. number of propositions, as well as number of arguments determine reading times;
6. propositions are recalled best if they are high in the hierarchical structure of the text base —whatever the precise theory of such a structure may be;
7. text and context determine the comprehension and further processing of sentences;
8. each discourse is assigned an explicit propositional text base, from which information can be drawn for various tasks (recall, questions, etc.) independently of their explicit appearance in surface structure;
9. recall has its own output constraints, is non-verbatim for sentences and discourse, is reconstructive, and only in the first few minutes added by surface information.

6.2. A number of these conclusions had been made earlier in cognitive

psychology, but they now have received solid experimental and theoretical foundations. They are all of primary importance in a theory of verbal information processing. One of the advantages of Kintsch's work is that it was radically chosen for semantic processing and for paragraph and discourse material. All our normal linguistic tasks, our knowledge and inferences, comprehension and production have semantic character, whereas the interpretation and organization of propositions is always dependent of its function within the discourse. Measures of complexity, acceptability, etc. should always be taken in relation to the structure of the whole discourse. Although in some cases the exposition of the logico-linguistic framework was too short and although a certain number of corrections and additions are necessary, even in RMM's simplified version, in order to account for the basic properties of textual structure, Kintsch has fully profited from the richness of actual linguistic theories as a foundation for a processing model. At the same time, he firmly stays within the most interesting traditions of cognitive psychology (stressing e.g. the reconstructive nature of language use and hence of recall and memory) and using the established results from verbal learning experiments. He thus not only contributed to psychology, but also to linguistics by showing the psychological relevance of grammatical constructs like proposition, case relations, surface structure and abstract (semantic) structure, text-base, presupposition, and so forth.

6.3. Finally, RMM suggests lines for further research. The main focus of the book was on the semantic structure of complex sentences and paragraphs. At this level of the linear structure of text-base fragments, a great number of further experiments can be carried out: Different types of connections between propositions must be made explicit and tested, as well as degrees of coherence (number of identical terms, distances between possible worlds, number of possible deletions of propositions from the text base), relations with surface structure, the difference between complex sentences and sequences of sentences in comprehension, the interaction with pragmatic constraints (knowledge of context) and with other types of information, e.g. visual and sensori-motor information. Clearly, for such experiments a serious, text- and context-sensitive grammar is necessary, of which only limited fragments are available at the moment. The psychologist, however, need not await such a full grammar and may carry out experiments with the theoretical fragments available.

Another line of research, now being undertaken by Kintsch and others, pertains to more global structures of discourse. In RMM those discourse structures were studied which could still be processed at the level of the propositions of the text base. When more complex and larger amounts of propositions must be handled, a series of new problems arise: structures must be made explicit for the discourse as a whole (schemata, frames or macro-structures) and these must be related with the structures of the linear text base. What do we recall of longer stories, immediately and after longer delays, which propositions are recalled and

which are erased or integrated and why? How do macro-structures for different types of discourses differ and how do these different structures affect memory? How are input structures related with and integrated into present information (knowledge) in memory? What are the relations of propositional information with other kinds of cognitive abilities (perception, action, etc.)? These and many other questions must be formulated in more explicit detail and systematically be tested. Instead of only concentrating on the construction of linguistic and logical models, as is now usual in cognitive psychology and artificial intelligence, more attention might be paid to the properties of processing itself: no linguist can at the moment provide a full grammar, we have to work on important sub-domains and crucial problems, of which the psychologist may test the cognitive implications.

The properties (rules, processes, strategies) of processing however have their own specific nature, and following the linguistic models too close may introduce biases which often require later correction (as in the tests about the psychological reality of syntactic phrase structure rules, categories and transformations). We do not read, comprehend and store discourse following formal rules alone, but we use expedient strategies which guarantee optimal understanding and organization of the information we receive and produce. In this respect it is absolutely necessary to begin to introduce the main results from pragmatics, socio-linguistics and social psychology: we do not interpret discourses independent of their pragmatic and social context, and we only store and use information which is relevant with respect to our social interactions.

TEUN A. VAN DIJK  
*University of Amsterdam*

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