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The interaction between textual structures and prior knowledge: Hypotheses, data and simulations

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Our purpose was to compare the effect of two types of textual semantic coherence – causal and teleological – on the organization of the mental representation elaborated after reading by learners with different levels of prior knowledge. Beginners, Intermediates and Advanced in computer domain read either the causal or the teleological version of a text describing three functions of a text editor, then performed a cued recall and a recognition task. We assumed that Advanced learners build a mental representation of the domain organized in a hierarchical goal/sub-goals structure, whereas Beginners and Intermediates have a mental representation organized in a causal path. If this is so, the results should indicate a significant interaction between prior knowledge and the semantic coherence of the texts: for the Advanced learners, recall and recognition of the teleological text should be better, whereas for the Beginners and Intermediates, the reverse was expected. As we assumed, results indicated that a teleological organization of textual information facilitated the comprehension of Advanced participants while a temporal-causal organization facilitated the comprehension of Beginner and Intermediate participants. The Construction-Integration model of Kintsch (1988, 1998) was used to simulate the recall results and to reproduce the effect of prior knowledge on the retrieval of textual information.

Introduction

According to van Dijk and Kintsch (1983), three levels must be distinguished in the memory representation of discourse: the surface, the textbase and the situation model. At the surface, a text is characterized by the exact words and sentences used. At the textbase, the local and global characteristics of the text are involved: the semantic content of the text is represented. At the situation model level, not only is the text itself represented, but also the situation described by the text. A number of studies have shown that these three levels of representation can be distinguished in sentence recognition experiments (Fletcher & Chrysler, 1990; Schmalhofer & Glavanov, 1986; Kintsch, Welsch, Schmalhofer, & Zimny, 1990). There

are usually differences in the retention of surface, textbase and situational levels of a text in that meaning is retained better than surface memory. By using different types of distractors in sentence recognition experiments, and by analyzing the differences between these types of test sentences, the memory trace at each level of representation may be estimated.

Several studies have suggested that text comprehension is dependent on prior knowledge. Voss and colleagues provided evidence that domain-specific knowledge influences reading (Chiesi, Spilich, & Voss, 1979; Means & Voss, 1985; Voss, Vesonder, & Spilich, 1980). They found that high-knowledge participants recalled more information than low-knowledge participants and concluded that the former employed their knowledge during reading to construct an organized representation of the text. Patel and Groen (1991a,b) and Schmidt and Boshuizen (1993), however, who studied the recall of clinical cases in three types of participants, novices, intermediates and experts in medicine, pointed out an Intermediate Effect on recall. Indeed, they demonstrated that intermediate participants recalled more information on a clinical case than expert participants. This result is surprising and difficult to explain. If we assume, as did Patel and Groen, that expertise is the upper limit of a continuum, we are unable to explain it. Patel and Groen (1991a,b) theorized that the experts selected relevant information using the macrostructure, whereas Schmidt and Boshuizen (1993) explained this result by expert encapsulation of knowledge, with detailed propositions initiated during comprehension getting encapsulated in concepts of great generality. Our hypothesis is that this Intermediate Effect depends on text structure: if the intermediate subjects recalled more information than the experts in the studies of Patel and Groen and Schmidt and Boshuizen, it is because the structure of the texts in question was closer to their prior knowledge organization than that of the experts.

The research reported in this article investigates the effect of two types of semantic coherence on the construction of a coherent mental representation by readers with different levels of knowledge – Beginners, Intermediates and Advanced – in the domain to be acquired, i.e., the use of a text editor on Macintosh. The two types of semantic coherence derive from the formalization of the mental and textual representations proposed by Denhière and Baudet (1992). These authors theorized that the cognitive representations elaborated after reading a text derive from the textbase and the subject's structure of knowledge and beliefs, i.e., his or her knowledge of the objects, states, events, actions, and relations represented in the text. Hence, they formalized the description of these mental and textual representations of a complex domain. According to them, the analysis of a complex system, such as a text editor, consists in (i) describing the units composing the system and the relations between these units in terms of a causal path, and (ii) making a teleological description of the system organized hierarchically into goal/sub-goals. The first description considers the relation between actions, events, and states according to the causal attributes (Trabasso & Sperry, 1985); the sequences of actions, events and states express the chronicle of the system's functioning. The second considers these sequences of actions, events and states as a hierarchy of goal/sub-goals, wherein the nodes subordinate to the original node represent the sub-goals of the text editor system whose attainment is conditional for the realization of the main goal of the system. These two system descriptions allowed us to construct two types of explanatory text that differed in their features of semantic coherence: causal or teleological. Baudet and Denhière (1991) showed that Advanced subjects organize the mental representation of a domain in a teleological structure, whereas Beginners and Intermediates organize it in a causal path. If this is indeed so, our experimental results should indicate an interaction between prior knowledge and the semantic coherence of texts. Jhean-Larose (1991) demonstrated this interaction in the domain of car mechanics: she found that the teleological organization of information to be learned facilitates the comprehension of Advanced participants because it is closer to their representation, whereas the temporo-causal organization facilitates, all other factors being equal, the comprehension of Beginners and Intermediates trying to introduce causal relations between the text elements.

Thus, the effect of causal and teleological structures on the comprehension performances of three groups of learners was investigated. First of all we conducted a preliminary

experiment to verify that learners elaborate a mental representation of the computer domain depending on the semantic structure of the text. Specifically, we wanted to determine the effect of the textual semantic coherence – causal versus teleological – on Beginners' comprehension of the Word Editor functions. Indeed, if the interaction observed by Jhean-Larose (1991) was due to the structure homology between prior knowledge and text i.e., hierarchical for Advanced and temporo-causal for Intermediates and Beginners, then the performances of the Beginners should differ as a function of the type of text – causal versus teleological. In this preliminary experiment, we therefore asked 40 Beginners to read one of the two versions of a procedural text, causal and teleological, and to perform a recognition task and a questioning. Results indicated that the comprehension performances of Beginners who read the causal text were better than of those who read the teleological text. Indeed, for the recognition task, the proportion of correct recognition of participants who read the causal text was higher than that of participants who read the teleological text ($F(1,38)=3.12$, $p<.08$), and for the questioning the proportion of correct answers to the questionnaire was significantly higher for the group which read the causal text compared with the group which read the teleological text ($F(1,38)=45.18$, $p<.01$). This preliminary experiment showed that causal and teleological structures have an effect on memorization and comprehension. Indeed, we noted that after reading the causal text, Beginners constructed a coherent representation of the studied domain, whereas reading the teleological text did not allow them to do so.

Given the results previously obtained (Baudet & Denhière, 1991; Jhean-Larose, 1991), and partially confirmed in the preliminary study, we present in this article an experiment in which cued recall and recognition performances of Beginners, Intermediates and Advanced were compared. We assumed that these three groups differed not only in the quantity of prior knowledge they possessed, but also in the organization of that knowledge. We further assumed that recall and recognition tasks would allow us to test our hypothesis of the structure homology between prior knowledge and texts. Although the effect of prior knowledge on text recall is well documented (Moravcsik & Kintsch, 1993; McNamara, Kintsch, Songer, & Kintsch, 1996), its effect on sentence recognition tasks remains unclear. Chiesi et al. (1979) showed that the recognition performances of high-knowledge subjects were better than those of low-knowledge subjects, whereas Dixon and colleagues (Dixon, Faries, & Gabrys, 1988; Dixon, Harrison, & Taylor, 1993) found that, in contrast to recall results, recognition performances did not vary as a function of background reading. The finding of Dixon et al., suggests that recall and recognition are differentially sensitive to aspects of the mental representation and that recall tasks require subjects to have a semantic representation of the text, whereas recognition tasks require them to be able to compare the surface structure of two sentences.

The Construction-Integration model proposed by Kintsch (1988) can be used as an interpretation framework for recall and recognition results. This model distinguishes the three levels of representation: surface structure, textbase and situation model (Kintsch, Welsch, Schmalhofer, & Zimny, 1990), and also takes into account the reader's knowledge during text comprehension (Kintsch, 1994). In this model, knowledge is represented as an associative network and the three levels of representation are seen as relations in an interrelated network of propositions. Text is processed in cycles roughly corresponding to a sentence, and two phases, construction and integration, are involved in sentence processing. In the construction phase, the text and knowledge elements are incorporated without any reference to the text, and many are inappropriate. The integration phase is characterized by a process of diffusion of the activation, reinforcing the elements appropriate to the context and inhibiting and deactivating the irrelevant elements. This results in a memory representation that is locally and globally well structured, and that can be represented as a coherent propositional network. From this representation, a reader can recognize sentences, answer questions, recall text, and so on. Simulations carried out with the Construction-Integration model and presented after the experimental investigations were used to investigate the role of prior knowledge in the construction of mental representations after reading, particularly in terms of text recall. Our main purpose was to test directly the differential knowledge structures of Intermediates and Advanced.

Experiment

Our purpose was to compare the effect of these two types of textual semantic coherence – causal and teleological – on the organization of the mental representation elaborated after reading by learners with different levels of prior knowledge. Beginners, Intermediates and Advanced read either the causal or the teleological version of a text describing three functions of a text editor, then performed a cued recall and a recognition task. We assumed that Advanced learners build a mental representation of the domain organized in a hierarchical goal/sub-goals structure, whereas Beginners and Intermediates have a mental representation organized in a causal path. If this is so, the results should indicate a significant interaction between prior knowledge and the semantic coherence of the texts: for the Advanced learners, recall and recognition of the teleological text should be better, whereas for the Beginners and Intermediates, the reverse was expected. Moreover, we expected that the Intermediates' recall of the causal text would be equal to or better than that of Advanced and that Advanced would recall more information than Intermediates after reading the teleological text.

Hence, we predicted an interaction between expertise and textual structure (Prediction 1). Advanced were expected to have a mental representation homologous to the teleological structure and Beginners and Intermediates were expected to have a representation homologous to the causal structure. Consequently, Beginners and Intermediates should have better performances after reading the causal text, whereas Advanced should have better performances after reading the teleological text. We predicted a greater performance difference between the causal and teleological texts for Beginners and Intermediates than for Advanced.

Besides, we predicted:

A level effect in reading times and recall protocols (Prediction 2). Sentences considered to be important should require shorter processing times and be more frequently recalled than other sentences (Denhière, 1982; Denhière & Deschênes, 1987; Tapiero, 1992). We assumed that this level effect would be more marked for Advanced than for Intermediates, and lowest for Beginners.

An interaction between recall cues and text (Prediction 3). Microstructural information should provide better retrieval cues than that of a higher level when the text is causal, whereas macrostructural information should provide better retrieval cues of information from the teleological text (Baudet, 1988; Denhière & Baudet, 1989).

An effect of the type of distractors on recognition times and subject accuracy (Prediction 4). The memory trace of Close semantic variations should be superior to that of Syntactic surface variations, Distant semantic variations being the most easily rejected. We predicted an interaction between the type of sentence to be recognized and the prior knowledge of subjects: (i) Verbatim recognition performances of Advanced should be better than those of Intermediates and Beginners and (ii) performances of Beginners and Intermediates should be better in terms of Surface distractors than those of Advanced, the surface structure playing a more important role for Beginners and Intermediates than for Advanced.

Method

Materials

Domain structure. The domain of knowledge comprised the description of three procedures in Microsoft WordTM: "*Select*", "*Cut*", and "*Paste*". We constructed two semantic structures explaining the procedures – one a causal description (temporo-causal structure) and the other a teleological description (hierarchical structure). These two structures are presented in Appendix 1.

Texts. Two texts were constructed from both types of semantic structure: a text with

causal coherence in which information was temporally and causally organized and a text with teleological coherence in which information was hierarchically organized in goal/sub-goals relation. Both types of text presented the same information and differed only in their mode of textual organization. They were composed of the same number of paragraphs and sentences (n=41) and connectives (n=7), and a similar number of propositions (199 vs 203), lines (59 vs 60), words (474 vs 495) and characters (2826 vs 2914). They were composed of identical sentences, which were, however, organized differently. These texts were subjected to a predicative analysis in which concepts are considered as propositions and thus as nodes in the associative network (Denhière, 1984; Kintsch, 1988).

In a pre-experiment, 30 students not directly involved in the experiment judged the relative importance of the sentences of both texts, causal and teleological, on a 6-point scale. After examining distributions, three levels of importance were selected – very important sentences, fairly important sentences and unimportant sentences[1].

Recall cues: Two recall cues were constructed. The first one from macrostructure (C1) only dealt with procedures of selection and referred more particularly to a sentence whose relevance was determined by the textual organization: "Recall all that you can about the different specific procedures of selection". The second from microstructure (C2) dealt with the Edit menu and referred to the three procedures presented: "*Select*", "*Cut*", "*Paste*". It did not refer to a particular sentence of the text: *"Recall all that you can about the edit menu"*. The recall protocols of the subjects were subjected to a predicative analysis. Each recalled proposition, referring to the cue, was coded either as identical to the read text, or as similar by acceptable variation of the predicate and the argument.

Recognition: For each type of text (causal and teleological), four types of sentences to be recognized were constructed: Verbatim, Syntactic surface variations, and Close and Distant semantic variations. Sixteen sentences were presented, four for each sentence type.

Apparatus

Texts were presented on a Macintosh computer screen using RRR software (Reading, Recall and Recognition) written by J. C. Verstiggel[2].

Participants

Ninety-six french students from 18 to 27 year-old of the University of Lyon 2, France, participated in the experiment. They were assigned to one of three groups according to their prior knowledge in the domain to be acquired: 32 Beginners, 32 Intermediates and 32 Advanced. This domain comprised three functions of Microsoft Word on Macintosh: "Select", "Cut" and "Paste". The participants were assigned to groups on the basis of oral questioning by an experimenter. The Beginners had never used an Editor, the Intermediates only knew Word Editor on "I.B.M. P.C." and the Advanced were daily users of Microsoft Word on Macintosh. Each group was divided into four sub-groups of eight participants assigned to one of the four experimental conditions: reading of the causal or teleological text, and text recall with microstructural cue or macrostructural cue.

Procedure

Participants were tested individually. The participants read one of the texts on computer at self pace, sentence by sentence, then immediately performed a written cued recall task limited to ten minutes. After this task, participants performed a recognition task.

Results

In order to estimate the relationship among the different dependant variables we used – Reading times, Proportion of proposition recall, Recognition times, Proportion of correct recognition – Spearman rho correlations were computed. Only the correlation between Reading times and Recognition times was significant, rho=.43, $p<.01$.

The variance analysis on reading time per proposition was conducted. The design for this analysis was a 3 (Prior knowledge) x 2 (Text) x 3 (Relative importance of information) factorial. Prior knowledge (Beginners, Intermediates, and Advanced) and Text (Causal and Teleological) were between-subjects variables and relative importance of information was manipulated within subjects.

A 3 (Prior knowledge) x 2 (Text) x 2 (Recall Cues) x 3 (Relative importance of information) x 2 (Recalled proposition Form) analysis was conducted on cued recall. Recall cues (microstructural and macrostructural) were between-subjects variables whereas Forms (identical and similar) were manipulated within-subject.

Two analyses were performed on recognition times: one analysis for verbatim sentences and one analysis for distractors, and two others on the subject accuracy. A 3 (Prior knowledge) x 2 (Text) x 3 (Verbatim or Distractor) analysis was conducted, Distractor being a within-subject variable.

Prediction 1: Interaction between expertise and textual structure

Consistent with our prediction 1, the Expertise * Text interaction was significant: $F(2,84)=6.33$ $p<.01$. The difference in proportion of recalled propositions between causal and teleological text was significantly greater for Beginners than for the other participants, $F(1,84)=3.79$ $p=.05$, and was greater for Intermediates than for Advanced: $F(1,84)=8.87$ $p<.01$, with an inversion of these differences for the latter (See Figure 1). Moreover, this interaction indicate an Intermediate Effect in the causal text recall (Patel & Groen, 1991a,b; Schmidt & Boshuizen, 1993): the Intermediates had better performances than Advanced participants for causal text recall. The analyses on the cognitive efficiency confirm this result: the difference in the cognitive efficiency ratio between causal and teleological text was not significant between Beginners and the other two groups, but was significantly greater for Advanced than for Intermediates, $F(1,90)=8.36$ $p<.01$.

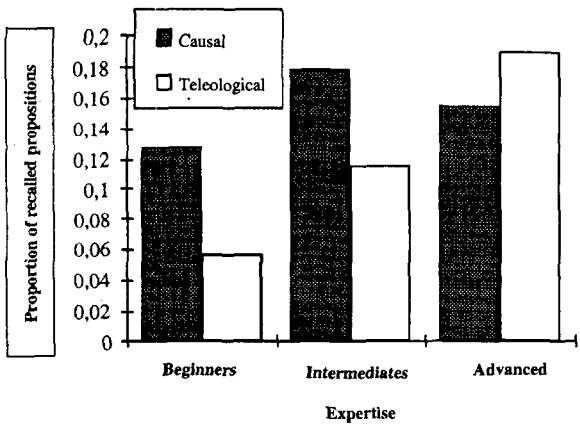


Figure 1. Proportion of recalled propositions as a function of the level of expertise and the semantic structure of texts

Prediction 2: Level effect in reading times and recall protocols

Consistent with our prediction 2, the effect of Relative importance on reading times was significant, $F(2,180)=72.01$ $p<.01$: the average reading time of the very important sentences (1369 ms) was significantly shorter than that of the other sentences (1460 ms), $F(1,180)=3.94$ $p<.05$, and the average reading time of the fairly important sentences (1146 ms) was significantly shorter than that of the unimportant sentences (1774 ms), $F(1,180)=140.6$ $p<.01$.

Moreover, we observed a level effect on cued recall protocols: $F(2,168)=211.59$ $p<.01$. The proportion of very important recalled propositions was significantly greater than that of the other propositions, $F(1,168)=326.29$ $p<.01$, and the proportion of fairly important recalled propositions was significantly greater than that of unimportant propositions, $F(1,168)=96.89$ $p<.01$. Thus, the probability for recalling a proposition varied as a function of its relative importance. The Relative importance * Expertise interaction which was also significant ($F(4,168)=5.6$ $p<.01$) mainly indicated that the difference in proportion of recalled propositions between the important sentences and the others did not significantly differ between Beginners and the others, but was greater for Advanced than for Intermediates, $F(1,168)=10.93$ $p<.01$ (see Figure 2). Finally, the significant form * Expertise interaction ($F(2,84)=10.27$ $p<.01$) indicated that the difference between identical and similar recalled propositions was significantly greater for Advanced than for Intermediates, identical being better recalled than similar propositions.

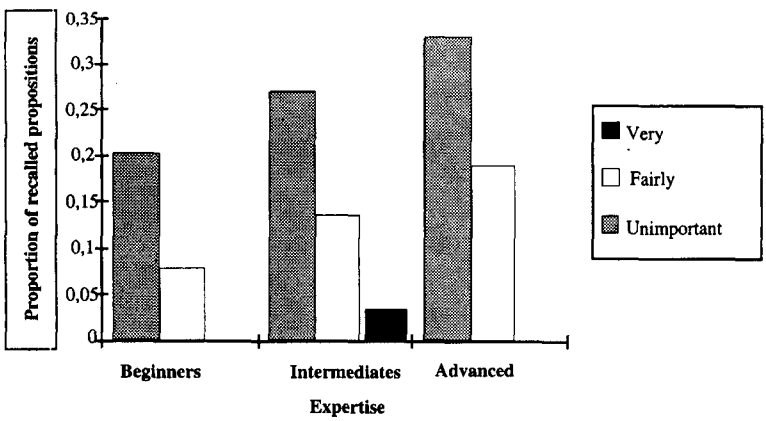


Figure 2. Proportion of recalled propositions as a function of the level of expertise and the relative importance of information

Prediction 3: Interaction between recall cues and text

Consistent with the prediction 3, the type of Recall cues * Text interaction was significant: $F(1,84)=5.19$ $p<.05$. When the text was causal, the proportion of recalled propositions with the microstructural cue was higher than with the macrostructural cue; whereas when the text was teleological, proportions were similar with the two types of cue.

Prediction 4: Interaction between prior knowledge and the type of sentences to be recognized

Recognition times. Expertise was significant for the distractor and verbatim analyses: $F(2,90)=18.14$ $p<.01$ for distractor; $F(2,90)=9.39$ $p<.01$ for verbatim. The mean recognition time of Beginners was longest ($F(1,90)=9.18$ $p<.01$ for distractors, $F(1,90)=2.22$ $p<.05$ for

verbatim – and that of Intermediates was longer than that of Advanced ($F(1,90)=27.11$ $p<.01$ for distractor, $F(1,90)=15.88$ $p<.01$ for verbatim).

Consistent with the prediction 4, the Expertise * Text interaction was significant but only for the distactors analysis, $F(2,90)=4,26$ $p<.05$: the difference in recognition time between causal and teleological text was greater for Beginners (2473.9 ms) than for the other participants (623.6 ms), $F(1,90)= 6.59$ $p<.05$, and did not significantly vary between Intermediates and Advanced, with the recognition time of sentences stemmed from causal text being the longest.

Distractor was significant, $F(2,180)=30.63$ $p<.01$: the mean recognition time of distractors was shorter for Distant semantic variations (3767.01 ms) than for Syntactic surface and Close semantic variations (5691.8 ms), $F(1,180)=60.92$ $p<.01$; and did not significantly differ between Syntactic surface and Close semantic variations ($p=0.16$). Although the Expertise * Distractor interaction was not significant, the Expertise * Text * Distractor interaction was significant, $F(4,180)=2.48$ $p<.05$. For Beginners, the difference in recognition time between causal and teleological texts was greater for Close semantic variations (3399 ms) than for Distant semantic variations (2455 ms), which was longer than Surface semantic variations (1566 ms). For Intermediates, the difference in recognition time between causal and teleological texts was greater for Surface semantic variations (2879 ms) than for the other types of distractors (3630 ms), whereas for the Advanced, this difference was similar for the three types of distractors.

Proportion of correct responses. Expertise was significant but only for the Yes responses: $F(2,90)=7.89$ $p<.01$. The proportion of correct "Yes" responses of Beginners (0,703) was significantly lower than that of the other participants (0.855), $F(1,90)=11.84$ $p<.01$, and that of Intermediates (0,805) was lower than that of Advanced (0,906), $F(1,90)=3.94$ $p=0.05$. The Expertise * Text interaction was not significant for the distractor analysis nor for the verbatim analysis.

Distractor was significant ($F(2,180)=297.02$ $p<.01$): the proportion of correct responses was greater for Distant semantic variations (0,969) than for Close semantic and Syntactic surface variations (0.393), $F(1,180)=543.28$ $p<.01$, and that of Close semantic variations (0.50) was higher than that of Syntactic surface variations (0.29), $F(1,180)=50.75$ $p<01$. The Expertise * Text * Distractor interaction was not significant.

Discussion

The results showed that subjects with different levels of expertise differed as regards reading times and proposition recall. The Expertise * Text interaction indicated that Beginners recalled more information after reading the text with causal coherence than after reading the text with teleological coherence. However, as we had foreseen, Advanced recalled more information after reading the teleological text, their representations being homologous to the teleological structure. As experienced users of the text editor, they had already acquired relevant knowledge and structured their representations into a tree with goal/sub-goal relations. The Intermediates had knowledge structures closer to those of Beginners and less elaborated than those of Advanced. They did not seem to have structured their knowledge in a teleological mode. However, they mastered the causal structure as well as the Advanced – indeed, to such an extent that they had higher performances than Advanced for recalling the causal text. Thus, we replicated the Intermediate Effect initially obtained by Patel and Groen (1991a,b) and Schmidt and Boshuizen (1993) in domains different from medicine. Our explanation of this effect as the result of the interaction between textual structure and prior knowledge was verified.

The Relative Importance * Expertise interaction showed that Advanced recalled relatively more important information than Intermediates and Beginners. Although the Advanced recalled less information than the Intermediates, the fact that it was more important indicated that they had elaborated a more efficient macrostructure and/or a more efficient retrieval

structure (Ericsson & Kintsch, 1995). The Form * Expertise interaction showed that Advanced recalled more identical information than other subjects. This result does not support the interpretation of Schmidt and Boshuizen (1993) on the Intermediate Effect. Our results showed that Advanced better memorized the surface structure than did Beginners and Intermediates. In this case, given the length of texts, it is difficult to imagine that they had used a knowledge encapsulation mode. Consequently, although Intermediate recalls were richer because they included more information, they nevertheless remained less close to the surface structure than those of Advanced. The interaction between the type of Recall cues and Text showed that the microstructural cue was more efficient for retrieving causal text, whereas it did not differ from macrostructural for the teleological text recall.

Consistent with predition 2, we observed a hierarchy in the reading and recall performances of the subjects: Advanced had the highest cognitive efficiency ratio, and Intermediates had a ratio higher than that of Beginners. The results also indicated a level effect on reading times and recall. Indeed, we observed that, while reading the explanatory texts, the participants took more time reading the sentences considered to be unimportant than those considered to be very important, and that the probability for recalling a proposition varied as a function to its relative importance: the more important a proposition was considered, the better it was recalled.

Last, the results showed that participants constructed different levels of representation during reading: surface structure, textbase and situation model. Consistent with the prediction 4, recognition times and proportion of correct responses varied with the type of distractors. The more distant a distractor was from the text, the more recognition performances increased. Thus, the Distant semantic variations were more often and more quickly rejected than the Close semantic variations, with the Syntactic surface variations leading to the most false recognitions. The results also indicated an effect of prior knowledge on verbatim recognition and on the rejection time of distactors: Advanced recognized verbatim more often and more quickly and rejected distractors more quickly than Intermediates and Beginners. Although the results did not indicate an interaction between prior knowledge and type of distractors for the correct responses, they showed that Advanced spent less time than the other subjects making a decision: recognition times seem to be more sensitive to prior knowledge than correct responses. Indeed, the Text * Distractor * Prior knowledge interaction revealed that: (i) for Beginners, text semantic coherence had a greater effect on recognition times of paraphrases than on those of other distractors, (ii) for Intermediates, semantic coherence had a greater effect on recognition times of Syntactic surface variations than on those of other distractors, (iii) for Advanced, semantic coherence did not have an effect on distractors recognition times. But inconsistent with our prediction, Beginners and Intermediates spent more time rejecting distractors after reading a causal text than a teleological text. From the recall results, we can assume that causal text allows Beginners and Intermediates to build a semantic representation and that teleological text does not. Consequently, after reading a causal text, Beginners and Intermediates are able to reject distractors by retrieving a semantic representation, which takes time, whereas, after reading teleological text, they use a surface representation permitting them to compare text and test sentences.

Simulations

We have attributed our experimental results to presumptive differences in the knowledge structure of Beginner, Intermediate and Advanced participants: temporo-causal for Beginner and Intermediate participants and teleological for Advanced participants. The recall results reported above support this claim. In the present section we show that a model of text comprehension can account for these results if and only if we assume that knowledge groups operate with different knowledge structures.

We use the construction-integration model of Kintsch (1988, 1998) to simulate the state of a subject's memory after reading the causal text when they recall text information. Notice that these simulations dealt with the cued recall of causal text, since the data indicated an Intermediate Effect (Patel & Groen, 1991a,b; Schmidt & Boshuizen, 1993), and with the

microstructural cue, which appeared to be a good retrieval cue of causal information. When reading the causal text, the relevant items of knowledge are automatically retrieved and linked with the appropriate text propositions. Thus, to simulate readers performances, knowledge structures are linked to the corresponding text propositions[3]. The text propositions and their pattern of interconnections via referential coherence were, of course, exactly the same for the prior knowledge groups, the only difference between the different simulations being the way in which the knowledge nodes were organized. We performed three different simulations of cued recall of causal text: A simulation of the textbase alone, of the textbase plus the prior knowledge of Intermediates, and of the textbase plus the prior knowledge of Advanced.

Method

Construction of prior knowledge networks: In order to obtain prior knowledge networks of Intermediates and Advanced, we asked ten Intermediates and ten Advanced participants, different from those being tested in the two studies, to report all that they knew about the "Edit" menu (microstrucural cue) without reading causal text[4]. From that, we selected concepts and predicates judged to be representative of prior knowledge. We linked these concepts and predicate nodes according to the organization of verbal protocol contents, and constructed two prior knowledge networks: one representative of the Intermediates' prior knowledge and a second representative of Advanced prior knowledge.

Simulation: To simulate the textbase, we linked the propositions to each other using referential coherence, and to simulate the role of prior knowledge, we linked prior knowledge nodes with textbase propositions. Figure 3 shows one sentence taken from the causal text: *Cut the word or words selected.* The textbase network of this sentence figures at the left while the prior knowledge network of Intermediates figures at the right. At each processing cycle, we linked proposition nodes to corresponding prior knowledge nodes. For example, the textbase node "P3" was linked to the corresponding prior knowledge node "PK CUT" and to the cued recall node "CR Edit menu". The number of links created between textbase networks and prior knowledge was greater for "Intermediate simulations" than for "Advanced simulations". For Advanced, only the textbase nodes judged to be important were linked to their prior knowledge nodes, whereas for Intermediates, all textbase nodes corresponding to prior knowledge nodes were linked together.

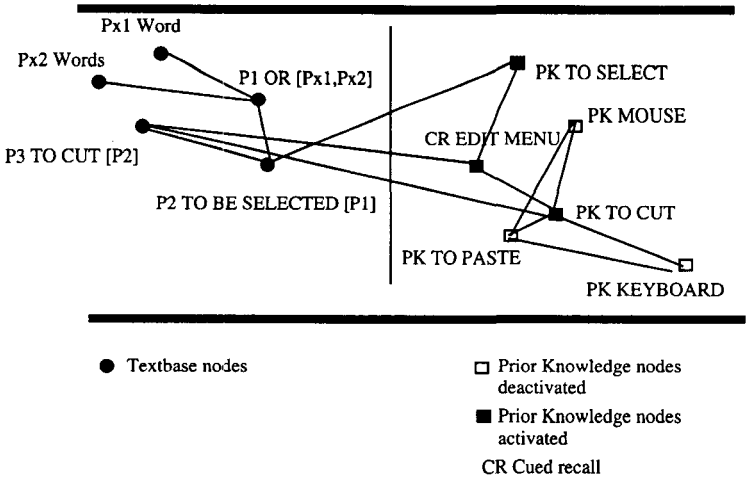


Figure 3. Simulation of the sentence: "Cut the word or words selected"

We obtained an activation value in long-term memory for each proposition. This value represented the weight in memory of the proposition and thus its probability of being recalled. The textbase nodes inherited the values of prior knowledge nodes if they were linked to them.

Results

These simulations – separate for Intermediates and Advanced – yielded a pattern of activation values for the text propositions and the corresponding knowledge nodes which is the model's estimate of the episodic long-term memory structure generated by Intermediates and Advanced when reading the causal text. It was assumed that the more highly activated a node becomes, the more it will be recall. Thus, activation values as calculated by the model and the empirically observed proportion of recalled proposition should be positively correlated.

The Spearman rho correlation between activation values and proportion of recalled propositions are presented in Table 1. The activation values obtained are in good qualitative agreement with the experimental data. The correlations obtained with prior knowledge networks were significantly different from 0, whereas those obtained with the textbase alone were close to 0. Thus, a model that did not include any prior knowledge (text propositions only) could not predict the results (rho>0 for both intermediates and advanced).

Table 1

Correlations between activation values and proportion of recalled propositions as a function of expertise and prior knowledge networks

RECALL	Textbase	TB+PK Intermediates	TB+PK Advanced
Intermediates	0.04	0.67**	0.36**
Advanced	0.03	0.50**	0.52**

Note. TB: Textbase; PK: Prior Knowledge; ** $p<.01$.

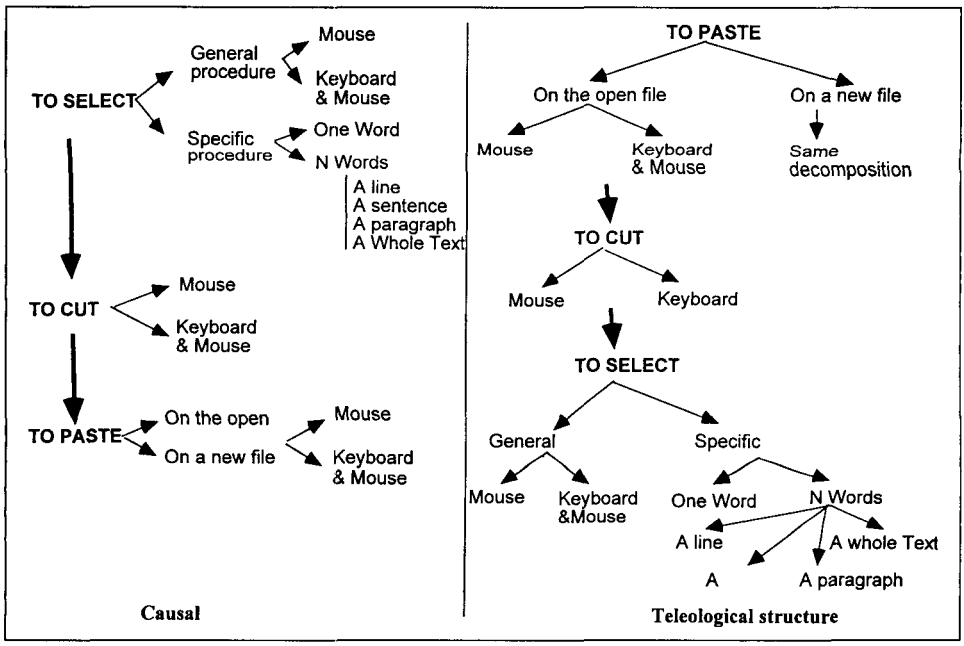
Conclusion

The interaction that we observed between the semantic structure of a text and the prior knowledge structure supports the hypothesis that Advanced have a representation of the domain of knowledge homologous to the teleological structure, and that Beginners and Intermediates organize their knowledge in a causal path. This interaction was previously demonstrated by Baudet and Denhière (1991) and Jhean-Larose (1993) with another domain, i.e. car mechanics. Our results also showed an Intermediate Effect: the recall performances of Intermediates exceeded those of Advanced after reading the causal text, whereas the reverse was observed for the teleological text. This Intermediate Effect suggests that expertise not only indicates a difference in the amount of knowledge in a domain but also implies a restructuration of the knowledge. Having already constructed a causal structure seems to be a precondition for constructing the teleological structure, which is achieved only with expertise. Thus, a Beginner, who is learning the functioning of a system, memorizes the information in a linear fashion and organizes it in a "causal path". With further knowledge, the Beginner will become Intermediate, and will progressively reach an Advanced level. How does an Intermediate become Advanced? We can assume that an Intermediate who is gathering information in a temporo-causal way will face, at a given moment, a problem of organization; the most efficient resolution to this problem will lead to a shift toward macroprocessing and the restructuration of knowledge.

Two implications, practical and theoretical, follow from these results. From a teaching point of view, it's necessary to take into account the cognitive porperties and, more precisely, to consider the prior knowledge structure of learners in the writing of procedural texts: the causal organization of information will facilitate the understanding from text of beginner and intermediate learners, whereas the teleological organization will facilitate that of avanced learners. From a theoretical point of view, these results suggest that a major difference between the prior knowledge organization of beginner, intermediates and advanced readers can be ascribed to the relationships among the goal, the necessary actions to attain the goal, and the outcome of these actions (Trabasso & van den Broek, 1985; Baudet & Denhière, 1991).

The simulation results show that Construction-Integration model proposed by Kintsch (1998) can be used to test the plausibility of hypotheses concerning the effect of prior knowledge structures on the elaboration of an episodic mental representation and on retrieval. By adding the appropriate prior knowledge network in the simulations, significant correlations between proportion of recalled propositions and activation were obtained. In fact, we can test assumptions on knowledge structure, on text representation, and on the interaction between these two representation systems by comparing activation values with participants' recall.

Appendix 1



Notes

1 Each sentence of the experimental texts was divided into segments. Subjects had to judge the relative importance of each segment on a 6-point scale. These values were assigned to three importance levels as a function of the distribution. Each proposition of a given segment inherited the value assigned to the segment. In this way, a value was assigned to each proposition of the causal and teleological texts.

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[3] We would like to thank Walter Kintsch for his many thoughful suggestions in the execution of these simulations.

[4] We did not obtain a prior knowledge network for Beginners because these subjects were unable to provide information about the "Edit" menu without reading text.

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L'objectif de cet article était d'appréhender l'effet de deux types de cohérence sémantique textuelle – causale et téléologique – sur l'organisation de la représentation mentale construite à l'issue de la lecture par des lecteurs de différents niveaux de connaissance. Des Débutants, des Intermédiaires et des Avancés dans le domaine informatique devaient lire soit la version causale, soit la version téléologique d'un texte décrivant trois fonctions d'un traitement de texte, puis devaient effectuer une épreuve de rappel indicé immédiatement suivie d'une tâche de reconnaissance. L'hypothèse testée était la suivante: les Avancés construiront une représentation mentale du domaine organisée en un arbre de but/sous-buts alors que les Débutants et les Intermédiaires élaboreront une représentation organisée en un chemin causal. En d'autres termes, nous nous attendions à observer une interaction entre les connaissances initiales des lecteurs et le type de cohérence textuelle: les performances de rappel et de reconnaissance des Avancés seront supérieures suite à la lecture du texte téléologique que suite à celle du texte causal alors que l'inverse est attendu pour les Débutants et Intermédiaires. Les résultats obtenus indiquent que l'organisation téléologique facilite la compréhension des Avancés alors que l'organisation temporo-causale facilite la compréhension des Débutants et Intermédiaires. Pour tester la plausibilité formelle de notre hypothèse, des simulations ont été réalisées dans le cadre du modèle Construction-Intégration de Kintsch (1988; 1998) et sont présentées après les résultats expérimentaux.

Key words: Causality, Prior knowledge, Simulation, Text comprehension.

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