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Influence of Expertise, Coherence, and Causal Connectives on Comprehension and Recall of an Expository Text

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5 It is reasonable to think that the optimal conditions for learning new text information, particularly in the case of scientific texts, is to encourage learners to process information by "searching for meaning" (Graesser, Singer, & Trabasso, 1994; van den Broek, 1990). However, the way a text is written may hinder the "search for meaning" and appropriate text processing. One case where this can occur is when the text contains inconsistencies which are difficult to resolve, particularly when the reader is a novice in the domain.

6 Local and global text coherence are considered by many theorists as particularly important to comprehension, i.e., to the construction of a mental text representation (Kintsch, 1988). Local text coherence refers to the fact that the propositions of the textbase processed in working memory must share common arguments; global coherence refers to the fact that the meaning of any textual information must match the situation model upon which the text's content is based.

7 Handbooks and instructional texts sometimes exhibit local and global incoherence, but text incoherence can often be resolved or at least improved. One way of doing so consists of adding new propositions and arguments to the original textbase to supply background information. Background information helps make the text locally coherent and thus facilitates its recall and comprehension (Britton & Gülgoz, 1991; Kintsch & Kintsch, 1995; McNamara, Kintsch, Songer, & Kintsch, 1996). Usually, the original text version is called the implicit version and the revised version, the explicit version.

8 Text coherence may also be improved and its comprehension facilitated by the presence of linguistic and relational markers, such as connectives. These devices enhance the text for two reasons. The first, emphasized by linguists (Halliday & Hasan, 1976), is that connectives make the text more cohesive and more structured by providing relationships between sentences. Moreover, connectives (e.g., *because, therefore, since, however, but, then, later,* and so on), explicitly tell the reader that the sentences are connected to each other in a precise semantic manner, namely, causal, restrictive, temporal, and so on (Bestgen & Vonk, 2000; Caron, Micko, & Thüring, 1988; Maury & Teisserenc, 2005; Mouchon, Ehrlich, & Loridan, 1999; Zwaan, 1996). Causal connectives may prompt readers to search for knowledge in long-term-memory in order to restore local or global text incoherence. For example, Caron et al. (1988) showed that when subjects had to recall the following two unrelated sentences:

9 a*) The priest was able to build the new church.*

10 b) The computer had made a serious error.

11 they recalled them better when they were connected by "because" than by "and". Maury et al. (2005) found similar results. It is possible that “because” prompted the readers to “search for meaning” by finding the reason underlying the semantic connection between the unrelated sentences. This search may have facilitate integration and memorization. The process that searches for this information is inference generation (Martins & Le Bouédec, 1998).

12 Although a number of authors have stressed the necessity of processing multiple mental dimensions – overall temporal, causal, and spatial - in text comprehension (Johnson-Laird, 1983), most have considered the causal dimension to be the most important for comprehension (Noordman & Vonk, 1998). For example, a number of investigators agree that the “greater the number of causal relations that readers identify in a text, the more coherent they perceive the text to be, and the better they remember it” (van den Broek, 1988; van den Broek, Tzeng, Risden, Trabasso, & Bashe, 2001).

13 Obviously, comprehension of causal connectives implies that the reader has knowledge of the signaled causal relations. If not, the causal connective is like an empty signal. So one can expect experts to benefit more than novices from such causal connectives during text comprehension. This was observed in a study by Noordman & Vonk (1992) in which experts in economy, but not novices processed the “because” connective in implicit versions. This result suggests that experts generate backward causal inferences that facilitate text comprehension.

14 Finally, another possible way of facilitating text comprehension is to add questions to the text. Earlier experimental studies have shown that adding questions improves comprehension and memory of passages (Davey & McBride, 1986; King, 1992; Martins, 1993). It is possible that questions direct attention not only to target information but also to all the content of the passage, and that this directed attention is accompanied by deeper processing and longer reading times (van den Broek et al., 2001).

15 The goal of this study was to look at how local text coherence, the addition of a causal connective, and the inclusion of questions affects scientific text comprehension and memorization. The procedure was taken from Kintch et al. (1995) and McNamara et al. (1996). The reading times of target sentences from coherent (explicit) and incoherent (implicit) versions of a text about biology were measured. We examined the role of the causal connective “that’s why” inserted at the beginning of a target sentence. Note that

there is very little causal-connective research on the comprehension of scientific texts, and also that the most common causal connectives analyzed so far have been “because” and “since”, which indicate to the reader that the target sentence is the cause of the consequence stated earlier in the text. This is why we thought it would be interesting to examine the role of a causal connective like “that’s why”. Finally, we looked at whether adding questions during reading facilitates text comprehension and memorization.

16 Our first hypothesis was that target sentence reading times are longer in implicit versions than in explicit versions: in implicit versions, readers try to integrate the content of the target sentence into the prior sentence by making an inference, which takes more processing time. Our second hypothesis was that adding questions increases the reading time of the target sentence. Our third hypothesis was that adding the connective “that’s why” increases reading time and improves memory and comprehension by signaling the consequence of a cause. Finally, our fourth hypothesis predicted an interaction between expertise and presence of connective on sentence reading times and performance. So the difference on reading times and on performance between the two groups should be greater with connective than without connective because experts possess a richer causally- related knowledge network about biology phenomena than novices. This background knowledge should allow experts to search more actively the causal meaning associated to connective “that’s why” than novices.

17 Thirty two novices, who were psychology students at the University of Paris X- Nanterre, and thirty two experts, who were biology students at the University of Paris XI- Orsay, participated on the experiment.

18 A text about the evolution of living organisms was prepared by the authors with the aid of biology teachers. It contained 44 sentences divided into 8 paragraphs, four in the explicit version and four in the implicit version. Paragraphs in explicit versions contained 6 sentences and an average of 111 words; paragraphs in implicit versions contain 5 sentences and an average of 83 words. Text is presented in Appendix.

19 Each paragraph contained a target sentence whose semantic content was a consequence of the preceding causal-inference sentence. The causal-inference sentence was present in explicit versions and absent in implicit ones. The supplementary inference sentences were taken from a pilot study in which 18 experts (biology teachers and experts others than those who participated in the experimental study) were asked to give the cause of the consequence described in the target sentences of the implicit versions of the paragraphs. So the causal supplementary sentence conveyed relevant information about the paragraph topic in which it was inserted and provided causally- pertinent knowledge for the consequence information in the target sentence.

20 The connective “That’s why” (*C'est pourquoi,* in French) preceded the target consequence sentence in half of the paragraphs, so this expression connected the target sentence to the previous sentence (the supplementary sentence) in explicit conditions. In implicit versions, the connective “That’s why” did not refer to any explicit cause in the text, so in this condition, the connective required making more inferential effort to connect the target sentence to the paragraph’s content.

21 Here is an example of the implicit and explicit versions of the first paragraph.

22 1)- The Earth’s existence depends on the solar system's formation within our galaxy, the Milky Way.

23 *2)- The Earth was formed 4.5 billion years ago, according to the most reasonable estimations.*

3)- During the first billion of years after Earth's formation, its temperature was exceptionally high.

Supplementary inference sentence in the explicit version:

- *Later, when the temperature dropped, the ideal conditions existed for the appearance of the first organic cells.*

Target sentence:

5)- Live organisms could appear only in the period called the Precambrian Era.

The target sentence was preceded in half of the paragraphs by the connective expression "That's why". So in this example, the target sentence was:

5 -That's why live organisms could appear only in the period called the Precambrian Era.

Eight text lists have been prepared in order to control presence and absence of the independent variables (questions, type of version, and presence of connective) in paragraphs. Each text list was presented for times to each group of participants.

Participants were instructed to read the text in order to understand it. They were informed that they had to answer two questions at the end of four paragraphs. The questions were inserted to ensure accurate text comprehension. Four of the questions (one per paragraph) were text-based and the other four (one per paragraph) required previous knowledge of the evolution of organisms, so they were related to the situation model (van Dijk & Kintsch, 1983).

In the questions related to the textbase, the reader had to produce, in writing, a missing word always situated in the target sentence. The situation model questions were about the content of the supplementary inference sentences in the explicit versions, which had been elaborated in the pilot study. So both types of questions were asked in half of the paragraphs, i.e., 4 questions related to the textbase and 4 questions related to the situation model.

The text was displayed one sentence at a time on a computer screen, in a controlled environment, so that reading times per sentence could be recorded. Pressing the space bar after reading a sentence erased the current sentence and displayed the next one.

When they had finished reading the eight paragraphs (that is, the whole text), participants answered eight unexpected questions about the content of four paragraphs, (the paragraphs that had no questions during reading). The form of these questions was the same as those presented during reading.

Here is an example of a question based on the text. Fill in the missing word:

Live organisms could appear only in the period called the ---------- Era.

Correct answer: Precambrian.

Example of a mental model question:

- *Why could living organisms appear only one billion years after the Earth's formation?*

Correct answer: Because the temperature was too high at the beginning, or because the temperature declined.

The questions were answered on an eight-page booklet. Participants were asked to write down their answers, with no time limit. The answers were scored by the experimenters. In the case of text-based questions, the score was either 0 (no answer or wrong answer) or 1 (word same as or similar to the one in the text). In the case of mental model questions,

the scores scale had the following possible scores: 0.0, 0.25, 0.50, 0.75 and 1. The highest score (1) was given when the answer expressed the idea described in the causal inference sentences of the explicit versions.

43 The experimental design was S 32 < E2 > V2 * C2 *Q2 * R2, where E2 was the level of expertise (novices and experts), V2 the type of version (explicit and implicit versions of paragraphs), C2 the presence or absence of the connective “that’s why” at the beginning of the target sentence, R2 the type of response to the questions (situation-model related and textbase-related).

44 The dependent variables were: reading times of target sentences and the correct responses to the questions during and after reading the text.

45 Target-Sentence Mean Reading Times as a Function of Expertise, Paragraph Version and Addition of Questions and the Connective “That’s why”.

46 We present now statistical analyses of target sentence reading times. Similar results have been observed when these reading times were divided by the number of words of target sentences.

47 The Mean reading time of the target sentence tended to be higher for experts than for novices (6470 ms vs 6197ms), but this difference was not significant. The Mean reading time of the target sentences inserted in paragraphs with questions was higher than in paragraphs without questions (6762 ms vs 5905ms) ($F (1, 62) = 12.553$, $p < .000$). The presence of the connective "That’s why” increased reading time of target sentences (6613 ms vs 6054 ms) ($F (1, 62) = 8.340$ p, $< .005$). Implicit versions led to longer target-sentence reading times than explicit ones (6642 ms vs 6025 ms) ($F (1, 62) = 6.511$, $p < .013$).

48 The interaction between the versions and expertise was significant ($F (1, 62) = 5.130$, $p < .027$). Planned contrasts show that novices took more time to read target sentences in implicit versions than in explicit ones ($F (1, 62) = 5.120$, $p < .027$), but not experts. The means were 6678 ms and 5615 ms for novices, and 6504 ms and 6435 ms for experts, respectively. Moreover the triple interaction between version, expertise, and questions was significant ($F (1, 62) = 4.685$, $p < .034$), suggesting that novices and experts process information in different ways.

49 Table 1 presents the mean target-sentence reading times as a function of version, expertise and the presence of questions.

TABLE 1

Means reading time (in ms) as a function of version, expertise, and the presence of questions

	NOVICES		EXPERTS	
	With questions	Without questions	With questions	Without questions
Explicit versions	5749 ms	5486 ms	6876 ms	5995 ms
Implicit versions	7593 ms	5964 ms	6834 ms	6176 ms

50 For novices, planned contrasts showed that, in conditions with questions, implicit versions led to slower reading times than explicit ones (7593 ms *vs.* 5749 ms) (F (1, 62) = 15.515, p < .000). But in conditions without questions, there was no significant difference between explicit and implicit versions (5486 ms and 5964 ms). So, novices read target sentences longer only in the implicit condition with questions.

51 For experts, there was no significant difference between the two versions or between paragraphs with or without questions. So, these readers had a more homogeneous pattern of reading times. Although the interaction between expertise and presence of connective was not significant (Hypothesis 4), the superiority of reading times of experts, compared to novices, was greater with the connective (more 388 ms) than without the connective (more 159 ms). This result suggests that experts, in the presence of connective, try more actively than novices to comprehend the causal relation of the target sentence.

52 Given that the readers were informed at the beginning of each paragraph whether or not they would have to answer questions at the end of the paragraph, we expected longer reading times for sentences in paragraphs associated with questions than for ones without questions. The results confirmed this prediction: subjects took more time to read sentences (except target sentences) associated with questions than sentences without questions (35 347 ms *vs.* 32 029 ms) (F (1, 62) = 9.001, p < 003).

53 However, although the interaction is not significant, experts read paragraph sentences for the same amount of time with or without associated questions (35 635 ms and 33 672 ms). By contrast, novices took more time to read sentences associated with questions than ones without questions (35 059 ms *vs.* 30 387 ms) (F (1, 62) = 8.927, p < .004).

54 Thus, as in the conditions where the target sentences were inserted in implicit versions with questions, novices tended to differ from experts: when the paragraphs were associated with questions, novices read more slowly than when there were no questions. Experts, on the other hand, tended to read in a more homogeneous way, regardless of the presence or absence of questions at the end of paragraph.

55 Correct Responses as a Function of Expertise, Version, and Connective Presence

56 The data obtained during reading will be presented first, followed by the data obtained after reading, because the two conditions are not the same: the readers waited for questions during reading, but not after reading. Table 2 presents the mean percent of correct responses as a function of expertise, version, and connective presence during reading.

TABLE 2

Mean percent of correct responses as a function of expertise, connective presence, and version during reading.

NOVICES								EXPERTS							
TB	TB	TB	TB	SM	SM	SM	SM	TB	TB	TB	TB	SM	SM	SM	SM
E	E	I	I	E	E	I	I	E	E	I	I	E	E	I	I
Pc	Ac	Pc	Ac	Pc	Ac	Pc	Ac	Pc	Ac	Pc	Ac	Pc	Ac	Pc	Ac

84	70	52	78	51	57	20	27	86	75	81	88	76	59	32	41

TB = text-based questions. SM = situation-model questions.

E = explicit version. I = implicit version.

Pc= presence of the connective. Ac = absence of the connective

57 The experts outperformed novices for all questions pooled (sum of correct text-base and situation-model responses: 67 *vs.* 55, respectively) (F (1, 62) = 13.198, p <.000). Correct responses for situation-model questions were less frequent than for text-based questions (.45 *vs.* .77) (F (1, 62) = 122.766, p <.000). Explicit versions led to better performance than implicit ones (.70 *vs.* .52) (F (1, 62) = 17.496, p <.000). The interaction between the type of version and the type of question was significant (F (1, 62) = 15.605, p < .000). Text-based responses were similar in the two versions (.79 in explicit versions and .75 in implicit ones). However, situation-model responses were more frequent in explicit versions than in implicit ones (.61 and .30, respectively) (F (1, 62) = 38.032, p < .000).

58 These results are probably due to the fact that text-based answers (missing words) were always present in the target sentences of both versions, so readers had the opportunity to read them and perhaps recall them. By contrast, the situation-model answers were always absent in the implicit versions, so readers had to infer them, which is a more difficult task. The interaction between the version and connective presence was significant (F (1, 62) = 8. 723, p < 004). In the explicit versions, the connective tended to improve performance (with the connective .75, without .65) (F (1, 62) 2.869, p < .095); in the implicit versions, on the contrary, the connective lowered performance (with connective .46, without .59) (F1, 62 = 5.792, p < .019). There was no interaction between expertise and type of response (text-based or situation model), nor between expertise and type of version (explicit or implicit).

59 The results observed after text reading were similar to those during reading task. Experts outperformed novices for all questions pooled (sum of correct text-based and situation-model responses: .52 *vs.* .36, respectively) (F (1, 62) = 11.794, p <.001). Correct situation-model responses were less frequent than were correct text-based responses (.32 *vs.* .56) (F (1, 62) = 57.359, p <.000).

60 The interaction between the type of version and the type of question was significant (F (1, 62) = 10.672, p < 001). Situation-model responses were more frequent in explicit versions than in implicit ones (38% *vs.* 26%) (F = 1, 62) = 5. 09, p < .027). Text- based responses, on the other hand, were higher in implicit versions than in explicit ones (62 % *vs.* 50%) (F (1,62) = 4.573, p < .036). These results are similar to those observed during reading and show once again, on this delayed task, that it was difficult to infer information in the implicit versions. As during text reading, there was no interaction between expertise and type of response (text-based or situation-model), nor between expertise and type of version (explicit *vs.* implicit).

61 There was a positive correlation between text reading time (excluding target sentence reading time) and overall performance, i.e., with the sum of the correct responses on the two tasks, during and after reading (r = .255, p < .042). However, this correlation was

nonsignificant for novices (r = .07, p < 1), but significant for experts (r = .466, p < .008). This suggests that compared to novices, experts know how to make better use of their reading time to understand text information, given that the target reading times of the two groups were equivalent.

62 Adding the connective "that's why" and questions during reading increased the reading times of the target sentences. Probably, readers tried to process target sentences more deeply when they knew they had to answer questions and when the connective indicated a cause-consequence relationship between the target sentence and the sentence that preceded it. However, the increase in target sentence reading times in the connective conditions was also due to the fact that there were three more words (that's why).

63 Analysis of the reading times showed that experts and novices adopted different strategies during reading. Novices increased their reading time in the implicit versions but only when they had to answer questions. Because the implicit versions were locally non coherent, the novices were probably sensitive to the textbase and particularly to the absence of arguments and concepts shared by the target sentence and the sentence before it. So the increase in novices' reading time seems to reflect their difficulty making causal inferences and finding the correct response. Novices also had higher paragraph reading times when they were informed that a question would be asked at the end of the paragraph. By contrast, experts appeared to process the textual information in a more homogeneous manner. However, they read in a more effective and adapted way; their reading times correlated with their performance, contrary to novices. So experts and novices appear to adopt different strategies for reading and processing textual information. Kintsch et al. (1995) and McNamara et al. (1996) suggested that experts adopt a different processing strategy from that of novices. For example, unlike novices, they appeared to be more interested in the implicit version of expository text than in the explicit version.

64 Contrary to the fourth hypothesis, the interaction between expertise and presence of connective on reading times was not significant. However experts were more sensible than novices to the causal connective; indeed their superiority in reading times – compared to novices – appeared especially in reading target sentences associated with the connective.

65 Experts achieved better overall performance. This result was expected: a number of studies have shown that experts tend to perform better than novices because they possess general knowledge schemas that allow them to receive and integrate new information (Denhière & Baudet, 1992; Tardieu, Ehrlich, & Gyselinck, 1992).

66 We found that situation-model responses were less frequent than text-based ones. This result is classic in the literature and is interpreted to mean that situation-model representations are more difficult to elaborate than textbase ones: the former are based on a text comprehension process whereas later require text memorization. However, no interaction was observed between expertise and the type of question, nor between expertise and connective. This result suggests that experts did not differ from novices in questions related to the situation model. Biology students probably do not have accurate knowledge of the evolution of living organisms. Most of the biology students on this study were beginning their university biology studies.

67 However, we can speculate that certain concepts were more familiar to the experts, for example, the idea of evolution and technical words such as Precambrian, Cambrian, and

Carboniferous. It is possible that this general familiarity facilitated text comprehension among the experts. Another explanation could be the fact that our biology students possessed what Kieras (1985) called "general procedures of reading" and "robust procedures to infer information" which made it easy for them to draw inferences in the domain in which they had some knowledge. In the same vein, McNamara (2004) showed that both high and low biology- knowledge subjects can use logic and common sense ideas to facilitate scientific text comprehension. It is possible that our readers, especially the experts, used this type of knowledge to improve text comprehension and recall.

68 During reading, explicit versions led to better answers related to comprehension, that is, answers related to the situation model. Indeed, the interaction between questions and versions during reading showed that there was no difference in the recall of answers related to the textbase, no matter what version was at stake. This is due to the fact that this type of answer was always written in the target sentence, in both versions. It is possible that the correct information (missing word) remained activated in the reader's working memory when the question was placed immediately after target-sentence reading. By contrast, the number of correct responses related to the situation model was much lower in the implicit versions than in the explicit ones. The reason for this is that in implicit versions, readers had to infer the correct answer (which is not written in the text) and in most cases, they probably did not possess the correct information, not even the experts. In explicit versions, however, readers in both groups took advantage of the presence of inference information.

69 We also observed an interaction between questions and versions after the reading task, but in a different way: information related to textbase was recalled better in implicit versions than in explicit ones. In this case, the correct information had to be searched for in long-term memory. It is possible that, because the target-sentence reading times were longer in implicit versions than in explicit ones, this type of information (the word that belonged to the target sentence) was read for a longer time and processed better. So, this information was recalled better than the same information in explicit versions.

70 During reading, the connective tended to improve performance for explicit versions and lower performance for implicit versions. This effect suggests that connectives may improve comprehension when semantic relationships between sentences are explicitly, and presumably clearly, stated; in contrast, when the inferential gap is too great, readers may infer information that interferes with the correct response.

71 The goal of this research was to look at how making a text more locally coherent, adding a connective that signals a cause – effect relationship between the target sentence and the sentence before it, and adding questions during reading affect scientific text comprehension and memorization.

72 We found that during reading, making the text more coherent (explicit versions) increased the number of correct answers related to the situation model but did not improve the recall of the missing words from the target sentences. This result is due to the fact that the target sentence was always presented in its entirety in the implicit versions. The high recall level of the missing word suggests that this word was still active in working memory on the immediate recall test. Another process may account for the better results of the situation-model-related responses in explicit versions: the presence of inference sentence made it easier to understand the cause–effect relationship.

73 Adding questions and the connective “that’s why” increased reading times, as expected, but the connective did not improve performance in the after-reading text task. These results are consistent with those obtained by Millis, Graesser, & Haberlandt (1993) who did not find positive effects of the causal connective “because” on the recall of fragments of encyclopedic text. Sanders & Noordman (2000) also found that positive effects of causal connectives are not always present in recall. Thus the positive effect of signaling causal relations appears to be transient. One possible reason for this is that connective processing is made too quickly and so does not permit a positive effect on long term memory. It is perhaps possible to enhance this type of processing by inviting readers to consider more deeply the semantic causal meaning of the causal connectives.

74 The connective “that’s why” tended to improve performance during the reading of explicit versions, while impairing performance in implicit versions. When the cause-consequence relation was clearly stated (explicit conditions) the connective probably highlighted it and thus enhanced comprehension and recall. It is possible that when there was no clear relation (implicit conditions) the connective acted like an empty signal; in these situations, readers tried to find an answer that was in fact wrong, and which may therefore have interfered with the correct one.

75 Target sentences were read for a longer time by novices, and only when they had to answer questions in implicit versions. This result suggests that the increase in reading times reflects an effort to understand in order to answer correctly in difficult processing conditions, knowing that the novices had very little knowledge of the evolution of the organisms.

76 Novices, but not experts, read for a longer time when they knew they had to answer questions. On the other hand, experts, but not novices, adapted their reading times to the comprehension process: their reading times were correlated with their performance. These results suggest two different ways of processing information; the novices wanted to answer the questions correctly and the experts wanted to understand the text.

77 Contrary to classic data, an interaction between the type of question and expertise was not observed. Also, explicit versions improved comprehension (situation-model responses) by novices but also by experts. These results suggest that the experts did not have accurate knowledge of the evolution of living organisms. This made the connective into an empty signal for them. These results prompt us to better define expertise in future research. Instead of simply using students in a discipline like biology, a specific test could be given before reading to better assess their knowledge level. Finally, it would be a good idea in future research to physically separate the connective from the target sentence to make it possible to precisely identify the effect of the connective on target sentence reading time.

78 Sentences were presented without figures and without paragraph numbers. I = Inference sentence presented only in explicit paragraph versions. Target sentence was preceded or not by the expression “C’est pourquoi” (That’s why).

79 Introduction

80 1 - On admet aujourd’hui que la formation de la Terre est due à des processus physico-chimiques complexes ayant engagé une nébuleuse primitive et un Soleil primitif appelé proto-soleil.

81 2 - Ces processus ont produit de très fortes températures et des énergies colossales.

82 Paragraphe 1

83 1 - L'existence de la terre est liée à la formation du système solaire au sein de notre galaxie, la Voie Lactée.

84 2 - La formation de la terre a eu lieu il y a 4,5 milliards d'années environ, selon les estimations les plus raisonnables.

85 3 - Pendant le premier milliard d'années qui suit sa formation, la température de la terre est extraordinairement élevée.

86 I - Puis, après son refroidissement, des conditions idéales se réunissent pour permettre l'apparition des premières cellules organiques.

87 4 - (C'est pourquoi) les êtres vivants n'ont pu faire leur apparition que dans la période qu'on appelle l'Ere Précambrienne.

88 5 - On appelle Précambrien cette Ere qui commence avec l'apparition des premiers êtres vivants constitués par des cellules et bactéries primitives.

89 Paragraphe 2

90 6 - Ensuite, au cours des temps précambriens, des organismes photosynthétiques (par exemple des Algues bleues) apparaissent.

91 7 - Les organismes photosynthétiques qui utilisent l'énergie solaire et des molécules minérales pour se nourrir, changent complètement « l'ambiance » de la Planète Terre en produisant de l'oxygène et son corollaire, l'ozone.

92 I - L'ozone des hautes couches atmosphériques forme une protection contre les radiations ultraviolettes nocives du soleil, ce qui permet à l'ensemble des êtres vivants de se développer sans dommage.

93 8 - (C'est pourquoi) la faune et la flore peuvent se développer et se diversifier très fortement.

94 9 - Dans la dernière phase du Précambrien – ou Ere précambrienne - on voit apparaître les métazoaires qui sont des êtres formés d'un grand nombre de cellules.

95 10 - Le Précambrien dura 3 milliards d'années environ.

96 Paragraphe 3

97 11 - À l'issue du Précambrien vont se dérouler les « Eres géologiques » dont la première est appelée Ere Primaire.

98 12 - La plupart des grands schémas d'organisation de la vie vont se mettre en place pendant l'Ere Primaire.

99 13 - Les premiers Vertébrés (parmi lesquels les agnates – poissons sans mâchoire) font leur apparition et côtoient les Invertébrés dans le milieu aquatique.

100 14 - Après une grande diversification qui dura des millions d'années, certains Vertébrés commencent, petit à petit, à coloniser la Terre.

101 I - Au cours de cette colonisation, ces animaux retournent dans l'eau pour pondre leurs œufs car ceux-ci ne bénéficient pas encore de la protection du liquide amniotique contenu dans les coques et ne peuvent donc pas éclore sur la terre ferme.

102 15 - (C'est pourquoi) les Amphibiens primitifs continuent, dans un premier temps, d'évoluer dans ces deux milieux naturels.

103 Paragraphe 4

16 - Vers le milieu de l'Ere Primaire, appelé époque dévonienne, Vertébrés et Invertébrés se sont déjà bien diversifiés.

17 - Au moment de l'éclosion des œufs, les Amphibiens (larves ou têtards) n'ont pas de pattes et doivent respirer l'oxygène dissous dans l'eau.

I - Puis, au cours de leur évolution, ils perdent leurs branchies et développent des poumons, grâce auxquels les reptiles peuvent désormais respirer l'oxygène de l'air.

18 - (C'est pourquoi) on appelle le processus de changement de larve aquatique en adulte vivant sur la terre ferme « processus de métamorphose ».

19 - Au terme de leur évolution, ces animaux ont acquis aussi 4 pattes : ils sont devenus tétrapodes.

20 - Les Amphibiens primitifs ont évolué en Reptiles au cours de l'époque suivante, appelée le Carbonifère.

Paragraphe 5

21 - Les Reptiles, parce que leurs œufs sont amniotiques, ont pu dépasser les capacités d'adaptation et de survie des Amphibiens.

22 - Pendant le Carbonifère, apparaît une lignée de Reptiles - le « Protoclépsidros »- qui va modifier la suite de l'évolution animale.

I – En effet le Protoclépsidros est le tout premier précurseur des Mammifères, car il présente des structures au niveau des os de la tête, du palais et des mandibules qui sont une première ébauche de ces structures présentes chez les Mammifères actuels.

23 – (C'est pourquoi) les Mammifères proprement dits apparaîtront beaucoup plus tard pendant l'Ere Secondaire.

24 – Toutes ces données sont tirées de l'étude des fossiles de Reptiles se trouvant dans des couches datant du Carbonifère.

25 - Le Carbonifère dura 100 millions d'années environ.

Paragraphe 6

26 - La faune et la flore, qui sont déjà très riches, vont encore évoluer sous des formes diverses et variées.

27 - Cette lointaine époque du Carbonifère est caractérisée, en milieu terrestre, par de grandes forêts, en particulier de fougères géantes.

I - C'est en effet à partir des restes laissés par les sédiments de ces fougères que le charbon peut se former.

28 - (C'est pourquoi) on admet que tous les gisements de charbon existant aujourd'hui dans le monde ont une origine extrêmement ancienne.

29 - En France et en Afrique du Sud les tortues terrestres connaissent un grand développement.

30 - Le Permien dura environ 40 millions d'années environ.

Paragraphe 7

31 - Vers le milieu et la fin du Permien les Reptiles continuent à se diversifier.

32 - Une nouvelle lignée de Reptiles, particulièrement importante par rapport à la formation des futurs Mammifères, apparaît alors.

127 I - Cette lignée, appelée « Thérapsidès », est importante car elle est constituée par une espèce de Reptiles qui sont des ascendants très proches, par l'évolution, du groupe des Mammifères.

128 33 - (C'est pourquoi) les Thérapsidès, sont la continuation dans la chaîne de l'évolution des Protoclépsidros.

129 34 - Les reptiles sont une classe d'animaux vertébrés tétrapodes.

130 35 - Leur peau est couverte d'écailles et leur respiration pulmonaire.

131 Paragraphe 8

132 36 - Certains Reptiles proches des Mammifères du point de vue de l'évolution ont acquis un mécanisme très primitif et rudimentaire.

133 37 - Le but de ce mécanisme est de maintenir invariante la température de leur corps par rapport à la température extérieure.

134 38 - Il s'agissait, chez ces Reptiles, d'épines neurales très allongées qui, parce qu'elles réagissaient à la température du milieu extérieur, augmentaient les facultés d'adaptation et de survie.

135 I - Ce mécanisme, disparu depuis chez les Reptiles, a auparavant été transmis aux Mammifères qui, en maintenant leur température corporelle stable, peuvent désormais mieux protéger leurs organes vitaux des aléas météorologiques.

136 39 - (C'est pourquoi) les Mammifères actuels sont des animaux à sang chaud particulièrement sensibles au froid et à la chaleur intenses.

137 40 - L'Ere Primaire dura 300 millions d'années environ.

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ABSTRACTS

Experts and novices read a biology text whose paragraphs were or were not accompanied by questions. The Text paragraphs contained target sentences that were locally coherent or incoherent and preceded or not preceded by the cause-effect connective "That's why". Connectives and questions during reading increased target sentence reading time. During reading, the coherent (explicit) text versions benefited from better comprehension of information related to the situation model, but not the recall of textbase-related information. The Connective tended to improve text recall and comprehension but only for the coherent (explicit) versions. More specific research on on-line processing should further examine how experts process causal connectives as compared to novices.

Des experts et des novices en biologie lisaient un texte sur l'évolution des espèces dont les paragraphes étaient (ou non) accompagnés de 2 questions, l'une de rappel, l'autre de compréhension. Chaque paragraphe comprenait une phrase cible – conséquence, localement cohérente ou non cohérente, qui était précédée (ou non) par l'expression causale "c'est pourquoi". L'ajout de l'expression causale et des questions augmente les temps de lecture de la phrase cible. Les informations relevant du modèle de situation sont mieux comprises dans les versions cohérentes (explicites) que dans les versions non cohérentes (implicites). Le connecteur causal tend à améliorer le rappel et la compréhension seulement dans les versions cohérentes (explicites). Dans la discussion, on souligne la nécessité de mieux examiner comment les experts, comparés aux novices, traitent les connecteurs causaux au cours même de la lecture.

INDEX

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