Active Reading

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By Dr Fiona McPherson

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Working memory, expertise & retrieval structures

In a 1987 experiment (1), readers were presented with a text that included one or other of these sentences:

After doing a few warm-up exercises, John put on his sweatshirt and began jogging.

or

After doing a few warm-up exercises, John took off his sweatshirt and began jogging.

Both texts went on to say: John jogged halfway around the lake.

After reading the text, readers were asked if the word *sweatshirt* had appeared in the story. Now here is the fascinating and highly significant result: those who read that John had put on a sweatshirt responded "yes" more quickly than those who had read that he had taken off his sweatshirt.

Why is this so significant? Because it tells us something important about the reading process, at least in the minds of skilled readers. They construct mental models. If it was just a matter of the mechanical lower-order processing of letters and words, why would there be a difference in responses? Neither text was odd — John could as well have put on a sweatshirt before going out for a jog as taken it off — so there shouldn't be a surprise effect. So what is it? Why is the word *sweatshirt* not as tightly / strongly linked in the second case as it is in the first? If they were purely textbase links (links generated by the textbase itself), the links should be equivalent. The difference in responses implies that the readers are making links with something outside the textbase, with a mental model.

Mental models, or as they are sometimes called in this context, situation models, are sometimes represented as lists of propositions, but in most cases it seems likely that they are actually analogue in nature. Thus the real world should be better represented by the situation model than by the text. Moreover, a spatial situation model will be similar in many ways to an image, with all the advantages that that entails.

All of this has relevance to two very important concepts: working memory and expertise.

Now, I'm always talking about working memory. This time I want to discuss not so much the limited attentional capacity that is what we chiefly mean by working memory, but another, more theoretical concept: the idea of long-term working memory.

Think about reading. To make sense of the text you need to remember what's gone before — this is why working memory is so important for the reading process. But we know how limited working memory is; it can only hold a very small amount — is it really possible to hold all the information we need to make sense of what we're reading? Shouldn't there be constant delays as we access needed information from long-term memory? But there aren't.

It’s suggested that the answer lies in the use of long-term working memory, a retrieval structure that keeps a network of linked propositions readily available.

Think about when you are studying / reading a difficult text in a subject you know well. Compare this to studying a difficult text in a subject you don’t know well. In the latter case, you may have to painfully backtrack, checking earlier statements, trying to remember what was said before, trying to relate what you are reading to things you already know. In the former case, you seem to have a vastly expanded amount of readily accessible relevant information, from the text itself and from your long-term memory.

The connection between long-term working memory and expertise is obvious. And expertise has already been conceptualized in terms of retrieval structures (see for example my article on expertise). In other words, you can increase your working memory in a particular domain by developing expertise, and the shortest route to developing expertise is to concentrate on building effective retrieval structures.

One of the areas where this is particularly crucial is that of reading scientific texts. Now we all know that scientific texts are much harder to process than, for example, stories. And there are several reasons for that. One is the issue of language: any science has its own technical vocabulary and you won't get far without knowing it. But another reason, far less obvious to the untutored, concerns the differences in structure — what may be termed differences of genre.

Now it might seem self-evident that stories are far simpler than science, than any non-fiction texts, and indeed a major distinction is usually made between narrative texts and expository texts, but it’s rather like the issue of faces and other objects. Are we specially good at faces because we're 'designed' to be (i.e., we have special 'expert' modules for processing faces)? Or is it simply that we have an awful lot of practice at it, because we are programmed to focus on human faces almost as soon as we are born?

In the same way, we are programmed for stories: right from infancy, we are told stories, we pay attention to stories, we enjoy stories. Stories have a particular structure (and within the broad structure, a set of sub-structures), and we have a lot of practice in that structure. Expository texts, on the other hand, don't get nearly the same level of practice, to the extent that many college students do not know how to handle them — and more importantly, don't even realize that that is what they're missing: a retrieval structure for the type of text they're studying.

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Understanding scientific text

In the last part I talked about retrieval structures and their role in understanding what you’re reading. As promised, this month I’m going to focus on understanding scientific text in particular, and how it differs from narrative text.

First of all, a reminder about situation models. A situation, or mental, model is a retrieval structure you construct from a text, integrating the information in the text with your existing knowledge. Your understanding of a text depends on its coherence; it's generally agreed that for a text to be coherent it must be possible for a single situation model to be constructed from it (which is not to say a text that is coherent is necessarily coherent for *you* —that will depend on whether or not *you* can construct a single mental model from it).

There are important differences in the situation models constructed for narrative and expository text. A situation model for a narrative is likely to refer to the characters in it and their emotional states, the setting, the action and sequence of events. A situation model for a scientific text, on the other hand, is likely to concentrate on the components of a system and their relationships, the events and processes that occur during the working of the system, and the uses of the system.

Moreover, scientific discourse is rooted in an understanding of cause-and-effect that differs from our everyday understanding. Our everyday understanding, which is reflected in narrative text, sees cause-and-effect in terms of goal structures. This is indeed the root of our superstitious behavior — we (not necessarily consciously) attribute purposefulness to almost everything! But this approach is something we have to learn not to apply to scientific problems (and it requires a lot of learning!).

This is worth emphasizing: science texts assume a different way of explaining events from the way we are accustomed to use — a way that must be learned.

In general, then, narrative text (and 'ordinary' thinking) is associated with goal structures, and scientific text with logical structures. However, it's not quite as clear-cut a distinction as all that. While the physical sciences certainly focus on logical structure, both the biological sciences and technology often use goal structures to frame their discussions. Nevertheless, as a generalization we may say that logical thinking informs experts in these areas, while goal structures are what novices focus on.

This is consistent with another intriguing finding. In a comparison of two types of text —ones discussing human technology, and ones discussing forces of nature — it was found that technological texts were more easily processed and remembered. Indications were that different situation models were constructed — a goal-oriented representation for the technological text, and a causal chain representation for the force of nature text. The evidence also suggested that people found it much easier to make inferences (whether about agents or objects) when human agents were involved. Having objects as the grammatical subject was clearly more difficult to process.

Construction of the situation model is thus not solely determined by comprehension difficulty (which was the same for both types of text), but is also affected by genre and surface characteristics of the text.

There are several reasons why goal-oriented, human-focused discourse might be more easily processed (understood; remembered) than texts describing inanimate objects linked in a cause-effect chain, and they come down to the degree of similarity to narrative. As a rule of thumb, we may say that to the degree that scientific text resembles a story, the more easily it will be processed.

Whether that is solely a function of familiarity, or reflects something deeper, is still a matter of debate.

Inference making is crucial to comprehension and the construction of a situation, because a text never explains every single word and detail, every logical or causal connection. In the same way that narrative and expository text have different situation models, they also involve a different pattern of inference making. For example, narratives involve a lot of predictive inferences; expository texts typically involve a lot of backward inferences. The number of inferences required may also vary.

One study found that readers made nine times as many inferences in stories as they did in expository texts. This may be because there are more inferences required in narratives — narratives involve the richly complex world of human beings, as opposed to some rigidly specified aspect of it, described according to a strict protocol. But it may also reflect the fact that readers don't make all (or indeed, anywhere near) the inferences needed in expository text. And indeed, the evidence indicates that students are poor at noticing coherence gaps (which require inferences).

In particular, readers frequently don't notice that something they're reading is inconsistent with something they already believe. Moreover, because of the limitations of working memory, only some of the text can be evaluated for coherence at one time (clearly, the greater the expertise in the topic, the more information that can be evaluated at one time — see the discussion of long-term working memory). Less skilled (and younger) readers in particular have trouble noticing inconsistencies within the text if they're not very close to each other.

Let's return for a moment to this idea of coherence gaps. Such gaps, it's been theorized, stimulate readers to seek out the necessary connections and inferences. But clearly there's a particular level that is effective for readers, if they often miss them. This relates to a counter-intuitive finding — that it's not necessarily always good for the reader if the text is highly coherent. It appears that when the student has high knowledge, and when the task involves deep comprehension, then low coherence is actually better. It seems likely that knowledgeable students reading a highly coherent text will have an "illusion of competence" that keeps them from processing the text properly. This implies that there will be an optimal level of coherence gaps in a text, and this will vary depending on the skills and knowledge base of the reader.

Moreover, the comprehension strategy generally used with simple narratives focuses on referential and causal coherence, but lengthy scientific texts are likely to demand more elaborate strategies. Such strategies are often a problem for novices because they require more knowledge than can be contained in their working memory. Making notes (perhaps in the form of a concept map) while reading can help with this.

Next month I'll continue this discussion, with more about the difficulties novices have with scientific texts and what they or their teachers can do about it, and the problems with introductory textbooks. In the meantime, the take-home message from this is:

Understanding scientific text is a skill that must be learned;

Scientific text is easier to understand the more closely it resembles narrative text, with a focus on goals and human agents;

How well the text is understood depends on the amount and extent of the coherence gaps in the text relative to the skills and domain knowledge of the reader.

References:

Otero, J., León, J.A. & Graesser, A.C. (eds). 2002. The psychology of science text comprehension.

Novices' problems with scientific text

This is the last part in my series on understanding scientific text. In this part, as promised, I am going to talk about the difficulties novices have with scientific texts; what they or their teachers can do about it; and the problems with introductory textbooks.

The big problem for novices is of course that their lack of knowledge doesn't allow them to make the inferences they need to repair the coherence gaps typically found in such texts. This obviously makes it difficult to construct an adequate situation model. Remember, too, that to achieve integration of two bits of information, you need to have both bits active in working memory at the same time. This, clearly, is more difficult for those for whom all the information is unfamiliar (remember what I said about long-term working memory last month).

But it's not only a matter a matter of having knowledge of the topic itself. A good reader can compensate for their lack of relevant topic knowledge using their knowledge about the structure of the text genre. For this, the reader needs not only to have knowledge of the various kinds of expository structures, but also of the cues in the text that indicate what type of structure it is. (see my article below on Reading scientific text for more on this).

One of the most effective ways of bringing different bits of information together is through the asking of appropriate questions. Searching a text in order to answer questions, for example, is an effective means of improving learning. Answering questions is also an effective means of improving comprehension monitoring (remember that one of the big problems with reading scientific texts is that students tend to be poor at judging how well they have understood what was said).

One of the reasons why children typically have pronounced deficits in their comprehension monitoring skills when dealing with expository texts, is that they have little awareness that expository texts require different explanations than narrative texts. However, these are trainable skills. One study, for example, found that children aged 10-12 could be successfully taught to use "memory questions" and "thinking questions" while studying expository texts.

Moreover, the 1994 study found that when the students were trained to ask questions intended to access prior knowledge/experience and promote connections between the lesson and that knowledge, as well as questions designed to promote connections among the ideas in the lesson, their learning and understanding was better than if they were trained only in questions aimed at promoting connections between the lesson ideas only (or if they weren't trained in asking questions at all!). In other words, making explicit connections to existing knowledge is really important! You shouldn't just be content to consider a topic in isolation; it needs to be fitted into your existing framework.

College students, too, demonstrate limited comprehension monitoring, with little of their self-questioning going deeply into the material. So it may be helpful to note Baker's 7 comprehension aspects that require monitoring:

- Your understanding of the individual words
- Your understanding of the syntax of groups of words
- External consistency — how well the information in the text agrees with the knowledge you already have
- Internal consistency — how well the information in the text agrees with the other information in the text
- Propositional cohesiveness — making the connections between adjacent propositions
- Structural cohesiveness —integrating all the propositions pertaining to the main theme
- Information completeness — how clear and complete the information in the text is

Think of this as a checklist, for analyzing your (or your students') understanding of the text.

But questions are not always the answer. The problem for undergraduates is that although introductory texts are presumably designed for novices, the students often have to deal not only with unfamiliar content, but also an approach that is unfamiliar. Such a situation may not be the best context for effective familiar strategies such as self-explanation.

It may be that self-explanation is best for texts that in the middle-range for the reader — neither having too little relevant knowledge, or too much.

Introductory texts also are likely to provide only partial explanations of concepts, a problem made worse by the fact that the novice student is unlikely to realize the extent of the incompleteness. Introductory texts also suffer from diffuse goals, an uneasy mix of establishing a basic grounding for more advanced study, and providing the material necessary to pass immediate exams.

A study of scientific text processing by university students in a natural situation found that the students didn't show any deep processing, but rather two kinds of shallow processing, produced by either using their (limited knowledge of) expository structures, or by representing the information in the text more precisely.

So should beginning students be told to study texts more deeply? The researchers of this study didn't think so. Because introductory texts suffer from these problems I've mentioned, in particular that of incomplete explanations, they don't lend themselves to deep processing. The researchers suggest that what introductory texts are good for is in providing the extensive practice needed for building up knowledge of expository structures (and hopefully some necessary background knowledge of the topic! Especially technical language).

To that end, they suggest students should be advised to perform a variety of activities on the text that will help them develop their awareness of the balance between schema and textbase, with the aim of developing a large repertory of general and domain-specific schemata. Such activities / strategies include taking notes, rereading, using advance organizers, and generating study questions. This will all help with their later construction of good mental models, which are so crucial for proper understanding.

References:

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Reading Scientific Text

There are many memory strategies that can be effective in improving your recall of text. However, recent research shows that it is simplistic to think that you can improve your remembering by applying any of these strategies to any text. Different strategies are effective with different types of text.

One basic classification of text structure would distinguish between narrative text and expository text. We are all familiar with narrative text (story-telling), and are skilled in using this type of structure. Perhaps for this reason, narrative text tends to be much easier for us to understand and remember. Most study texts, however, are expository texts.

Unfortunately, many students (perhaps most) tend to be blind to the more subtle distinctions between different types of expository structure, and tend to treat all expository text as a list of facts. Building an effective mental model of the text (and thus improving your understanding and recall) is easier, however, if you understand the type of structure you're dealing with, and what strategy is best suited to deal with it.

Identifying structure

Five common types of structure used in scientific texts are:

Generalization: the extension or clarification of main ideas through explanations or examples

Enumeration: listing of facts

Sequence: a connecting series of events or steps

Classification: grouping items into classes

Comparison / contrast: examining the relationships between two or more things

Let's look at these in a little more detail.

Generalization

In generalization, a paragraph always has a main idea. Other sentences in the paragraph either clarify the main idea by giving examples or illustrations, or extend the main idea by explaining it in more detail. Here's an example:

Irritability is defined as an organism's capacity to respond to conditions outside itself. ... The organism's response is the way it reacts to stimulus. For example, a plant may have a growth response. This happens when ...

Enumeration

Enumeration passages may be a bulleted or numbered list, or a list of items in paragraph form, for example:

There are four general properties of solids. Tenacity is a measure of ... Hardness is ... Malleability refers to ... Ductility is ...

Sequence

A sequence describes a series of steps in a process. For example:

Hearing can be described in five separate stages. First, ...

Classification

In classification, items are grouped into categories. For example:

Experimental variables can be grouped into one of two categories, either a manipulated variable or a controlled variable. A variable that can ...

Comparison / contrast

This type of text looks at relationships between items. In comparison, both similarities and differences are studied. In contrast, only the differences are noted. For example:

There are two different hypotheses for the origin of the earth: the nebular hypothesis and the comet-produced hypothesis. The nebular hypothesis maintains ... In contrast, the comet-produced hypothesis states ... The first hypothesis assumes ... The latter hypothesis asserts ...

[examples taken from Cook & Mayer 1988]

A study [1] involving undergraduate students inexperienced in reading science texts (although skilled readers otherwise) found that even a small amount of training substantially improved the students' ability to classify the type of structure and use it appropriately.

Let's look briefly at the training procedures used:

Training for generalization

This involved the following steps:

- identify the main idea
- list and define the key words
- restate the main idea in your own words
- look for evidence to support the main idea
- what kind of support is there for the main idea?
- are there examples, illustrations?
- do they extend or clarify the main idea?

Training for enumeration

This involved the following steps:

- name the topic
- identify the subtopics
- organize and list the details within each subtopic, in your own words

Training for sequence

This involved the following steps:

- identify the topic
- name each step and outline the details within each
- briefly discuss what's different from one step to another

[Only these three structures were covered in training]

Most effective text structures

Obviously, the type of structure is constrained by the material covered. We can, however, make the general statement that text that encourages the student to make connections is most helpful in terms of both understanding and memory.

In light of this, compare/contrast would seem to be the most helpful type of text. Another text structure that is clearly of a similar type has also been found to be particularly effective: **refutational** text. In a refutational text, a common misconception is directly addressed (and refuted). Obviously, this is only effective when there is a common misconception that stands in the way of the reader's understanding -- but it's surprising how often this is the case! Incompatible knowledge is at least as bad as a lack of knowledge in hindering the learning of new information, and it really does need to be directly addressed.

Refutational text is however, not usually enough on its own. While helpful, it is more effective if combined with other, supportive, strategies. One such strategy is elaborative interrogation, which involves (basically) the student asking herself **why** such a fact is true.

Unfortunately, however, text structures that encourage connection building are not the most common type of structure in scientific texts. Indeed, it has been argued that "the presentation of information in science textbooks is more likely to resemble that of a series of facts [and thus] presents an additional challenge that may thwart readers' efforts to organize text ideas relative to each other".

Most effective strategies

The fundamental rule (that memory and understanding are facilitated by any making of connections) also points to the strategies that are most effective.

As a general rule, strategies that involve elaborating the connections between concepts in a text are the most effective, but it is also true that the specifics of such strategies vary according to the text structure (and other variables, such as the level of difficulty).

Let's look at how such a linking strategy might be expressed in the context of our five structures.

Generalization

Restatement in your own words -- paraphrasing -- is a useful strategy not simply because it requires you to actively engage with the material, but also because it encourages you to connect the information to be learned with the information you already have in your head. We can, however, take this further in the last stage, when we look for the evidence supporting the main idea, if we don't simply restrict ourselves to the material before us, but actively search our minds for our own supporting evidence.

Enumeration

This text structure is probably the hardest to engage with. You may be able to find a connective thread running through the listed items, or be able to group the listed items in some manner, but this structure is the one most likely to require mnemonic assistance (see verbal mnemonics and list-learning mnemonics).

Sequence

With this text structure, items are listed, but there is a connecting thread — a very powerful one. Causal connections are ones we are particularly disposed to pay attention to and remember; they are the backbone of narrative text. So, sequence has a strong factor going for it.

Illustrations particularly lend themselves to this type of structure, and research has shown that memory and comprehension is greatly helped when pictures portraying a series of steps, in a cause-and-effect chain, are closely integrated with explanatory text. The closeness is vital — a study that used computerized instruction found dramatic improvement in memory when the narration was synchronous with the animation, for example, but there was no improvement when the narration was presented either before or after the text. If you are presented with an illustration that is provided with companion text, but is not closely integrated with it, you will probably find it helpful to integrate it with the text yourself.

Classification

Classification is frequently as simple as grouping items. However, while this is in itself a useful strategy that helps memory, it will be more effective if the connections between and within groups are strong and clear. Connections within groups generally emphasize similarities, while connections between groups emphasize both similarities (between closely connected groups) and differences. Ordering groups in a hierarchical system is probably the type of arrangement most familiar to students, but don't restrict yourself to it. Remember, the important thing is that the arrangement has meaning for *you*, and that the connections emphasize the similarities and differences.

Compare / contrast

This type of structure lends itself, of course, to making connections. Your main strategy is probably therefore to simply organize the material in such a way as to make those connections clear and explicit.

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Why good readers might have reading comprehension difficulties and how to deal with them

The limitations of working memory have implications for all of us. The challenges that come from having a low working memory capacity are not only relevant for particular individuals, but also for almost all of us at some points of our lives. Because working memory capacity has a natural cycle — in childhood it grows with age; in old age it begins to shrink. So the problems that come with a low working memory capacity, and strategies for dealing with it, are ones that all of us need to be aware of.

Today, I want to talk a little about the effect of low working memory capacity on reading comprehension.

A recent study involving 400 University of Alberta students found that 5% of them had reading comprehension difficulties. Now the interesting thing about this is that these were not conventionally poor readers. They could read perfectly well. Their problem lay in making sense of what they were reading. Not because they didn't understand the words or the meaning of the text. Because they had trouble remembering what they had read earlier.

Now these were good students — they had at least managed to get through high school sufficiently well to go to university — and many of them had developed useful strategies for helping them with this task: highlighting, making annotations in the margins of the text, and so on. But it was still very difficult for them to get hold of the big picture — seeing and understanding the text as a whole.

This is more precisely demonstrated in a very recent study that required 62 undergraduates to read a website on the taxonomy of plants. Now this represents a situation that is much more like a real-world study scenario, and one that has, as far as I know, been little studied: namely, drawing together information from multiple documents.

In this experiment, the multiple documents were represented by 24 web pages. Each page discussed a different part of the plant taxonomy. The website as a whole was organized according to a four-level hierarchical tree structure, where the highest level covered the broadest classes of plants ("Plants"), and the lowest, individual species. However — and this is the important point — there was no explicit mention of this organization, and you could navigate only one link up or down the tree, not sideways. Participants entered the site at the top level.

After pretesting, to assess WMC and prior plant knowledge, the students were given 18 search questions. Participants were asked both to read the site and answer the questions. They were given 25 minutes to do so, after which they completed a post-test similar to their pre-test of prior knowledge: (1) placing the eight terms found in the first three levels on the hierarchical tree (tree construction task); (2) selecting the correct two items from a list of five, that were subordinates to a given item (matching task).

Neither WMC nor prior knowledge affected performance on the search task. Neither WMC nor prior knowledge (nor indeed performance on the search task) directly affected performance on the post-test matching task, indicating that learning simple factual knowledge is not affected by your working memory capacity or how much relevant knowledge you have (remember though, that this was a very simple and limited amount of new knowledge).

But, WMC did significantly affect understanding of the hierarchical structure (assessed by the tree construction task). Prior knowledge did not.

These findings don't only tell us about the importance of WMC for seeing the big picture, they also provide some evidence of what underlies that, or at least what doesn't. The findings that WMC didn't affect the other tasks argues against the idea that high WMC individuals may be benefiting from a faster reading speed, or that they are better at making local connections, or that they can cope better at doing multiple tasks. WMC didn't affect performance on the search questions, and it didn't affect performance on the matching task, which tested understanding of local connections. No, the only benefit of a high WMC was in seeing global connections that had not been made explicitly.

Let's go back to the first study for a moment. Many of the students having difficulties apparently did use strategies to help them deal with their problem, but their strategy use obviously wasn't enough. I suspect part of the problem here, is that they didn't really realize what their problem was (and you can't employ the best strategies if you don't properly understand the situation you're dealing with!).

This isn't just an issue for people who lack the cognitive knowledge and the self-knowledge ("metacognition") to understand their intrinsic problem. It's also an issue for adults whose working memory capacity has been reduced, either through age or potentially temporary causes such as sleep deprivation or poor health. In these cases, it's easy to keep on believing that ways of doing things that used to work will continue to be effective, not realizing that something fundamental (WMC) has changed, necessitating new strategies.

So, let's get to the burning question: how do you read / study effectively when your WMC is low?

The first thing is to be aware of how little you can hold in your mind at one time. This is where paragraphs are so useful, and why readability is affected by length of paragraphs. Theoretically (according to 'best practice'), there should be no more than one idea per paragraph. The trick to successfully negotiating the hurdle of lengthy texts lies in encapsulation, and like most effective strategies, it becomes easier with practice.

Rule 1: Reduce each paragraph to as concise a label as you can.

Remember: “concise” means not simply brief, but rather, as brief as it can be while still reminding you of all the relevant information that is encompassed in the text. This is about capturing the essence.

Yes, it’s an art, and to do it well takes a lot of practice. But you don’t have to be a master of it to benefit from the strategy.

The next step is to connect your labels. This, of course, is a situation where a mind map-type strategy is very useful.

Rule 2: Connect your labels.

If you are one of those who are intimidated by mind maps, don’t be alarmed. I said, “mind map-type”. All you have to do is write your labels (I call them labels to emphasize the need for brevity, but of course they may be as long as a shortish sentence) on a sheet of paper, preferably in a loose circle so that you can easily draw lines between them. You should also try to write something by these lines, to express your idea of the connection. These labels will also provide a more condensed label for the ideas being connected. You can now make connections between these labels and the others.

The trick is to move in small steps, but not to stay small. Think of the process as a snowball, gathering ideas and facts as it goes, getting (slowly) bigger and bigger. Basically, it’s about condensing and connecting, until you have everything densely connected, and the information getting more and more condensed, until you see the whole picture, and understand the essence of it.

Another advantage of this method is that you will have greatly increased your chances of remembering it in the long-term!

In a situation similar to that of the second study — assorted web pages — you want to end up with a tight cluster of labels for each page, the whole of which is summed up by one single label.

What all this means for teachers, writers of text books, and designers of instructional environments, is that they should put greater effort into making explicit global connections — the ‘big picture’.

A final comment about background knowledge. Notwithstanding the finding of the second study that there was no particular benefit to prior knowledge, the other part of this process is to make connections with knowledge you already have. I’d remind you again that that study was only testing an extremely limited knowledge set, and this greatly limits its implications for real-world learning.

I have spoken before of how long-term memory can effectively increase our limited WMC (regardless of whether your WMC is low or high). Because long-term memory is essentially limitless. But information in it varies in its accessibility. It is only the readily accessible information that can bolster working memory.

So, there are two aspects to this when it comes to reading comprehension. The first is that you want any relevant information you have in LTM to be 'primed', i.e. reading and waiting. The second is that you are obviously going to do better if you actually have some relevant information, and the more the better!

This is where the educational movement to 'dig deep not broad' falls down. Now, I am certainly not arguing against this approach; I think it has a lot of positive aspects. But let's not throw out the baby with the bathwater. A certain amount of breadth is necessary, and this of course is where reading truly comes into its own. Reading widely garners the wide background knowledge that we need — and those with WMC problems need in particular — to comprehend text and counteract the limitations of working memory. Because reading widely — if you choose wisely — builds a rich database in LTM.

We say: you are what you eat. Another statement is at least as true: we are what we read.

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Press release on the first study: http://www.physorg.com/news/2012-01-high-school-whiz-kids-comprehension.html; see also http://rrl.educ.ualberta.ca/research.html

Second study: Banas, S., & Sanchez, C. a. (2012). Working Memory Capacity and Learning Underlying Conceptual Relationships Across Multiple Documents. *Applied Cognitive Psychology*, n/a-n/a. doi:10.1002/acp.2834

Using 'hard to read' fonts may help you remember more

Two experiments manipulating fonts to create texts that are slightly more difficult to read has found that such texts are better remembered.

It must be easier to learn when your textbook is written clearly and simply, when your teacher speaks clearly, laying the information out with such organization and clarity that everything is obvious. But the situation is not as clear-cut as it seems. Of course, organization, clarity, simplicity, are all good attributes — but maybe information can be *too* clearly expressed. Maybe students learn more if the information isn't handed to them on a platter.

A recent study looked at the effects of varying the font in which a text was written, in order to vary the difficulty with which the information could be read. In the first experiment, 28 adults (aged 18-40) read a text describing three species of aliens, each with seven characteristics, about which they would be tested. The control group saw the text in 16-point Arial, while two other versions were designed to be harder to read: 12-point Comic Sans MS at 60% grayscale and 12-point Bodoni MT at 60% grayscale. These harder-to-read texts were not noticeably more difficult; they would still be easily read. Participants were given only 90 seconds to memorize the information in the lists, and then were tested on their recall of the information after some 15 minutes doing other tasks.

Those with the harder-to-read texts performed significantly better on the test than those who had the standard text (an average of 86.5% correct vs 72.8%).

In the second experiment, involving 222 high school students from six different classes (English, Physics, History, and Chemistry, and including regular, Honors, and Advanced Placement classes), the text of their worksheets (and in the case of the physics classes, PowerPoint slides) was manipulated. While some sections of the class received the materials in their normal font, others experienced the text written in either Haettenschweiler, Monotype Corsiva, Comic Sans italicized, or smeared (by moving the paper during copying).

Once again, students who read the texts in one of the difficult conditions remembered the material significantly better than those in the control condition. As in the first study, there was no difference between the difficult fonts.

While it is possible that the use of these more unusual fonts made the text more distinctive, the fonts were not so unusual as to stand out, and moreover, their novelty should have diminished over the course of the semester. It seems more likely that these findings reflect the 'desirable difficulty' effect. However, it should be noted that getting the 'right' level of difficulty is a tricky thing — you need to be in the right place of what is surely a U-shaped curve. A little too much difficulty and you can easily do far more damage than good!

Reference:

[2285] Diemand-Yauman, C., Oppenheimer D. M., & Vaughan E. B. (2011). Fortune favors the (): Effects of disfluency on educational outcomes. Cognition. 118(1), 111 - 115.

Source:

http://medicalxpress.com/news/2011-06-hard-fonts-retention.html
http://www.miller-mccune.com/culture-society/clarity-not-always-the-best...

Speed Reading

Speed-reading courses generally make extravagant claims that no independent research has justified.

However, speed-reading courses **can** improve your reading skills.

Speed-reading courses principally improve reading by teaching you how to efficiently **skim**.

Speed-reading techniques

Like many memory improvement courses, speed-reading programs tend to make inflated claims. Also like memory programs, most speed-reading programs proffer the same advice. In essence, speed-reading techniques involve the following components:

- learning to see more in a single eye fixation
- eliminating subvocalization ("saying" the words in your head as you read them)
- using your index finger as a visual guide down the page
- active reading

How reading works

The first thing you need to understand about reading is that it proceeds in jerks. Though we might think our eyes are traveling smoothly along the lines, this is an illusion. What happens is that the eyes gaze steadily for around 240 milliseconds (for a college student; less practiced readers take longer) and then jerk along (during which nothing is registered), then stop again. We "read" during the eye fixations.

Now the duration of these fixations is not hugely different between readers of different abilities - a first-grade child takes about 330 ms, which is not a vast difference when you consider the chasm between a first-grade reader and an educated adult. What does change significantly is the *number* of fixations. Thus, to read a 100-word passage, our first-grade reader takes some 183 fixations, while our college reader takes only 75. From this, it is calculated that the first-grade reader is taking in 0.55 of a word in each fixation (100/183), while the college reader is grasping 1.33 words in each fixation (100/75). And from this, the reading rate is calculated. [These figures are of course only indicative - different types of reading matter will obviously produce different figures; the degree to which comprehension is emphasized also makes a difference].

This is not, of course, the whole story. We also can pick up some information about letters on either side of the fixation point - about 10 to 11 letter positions right of the fixation point (or left, if you're reading in a script that goes from right to left) for specific letter information, and about 15 positions for information about word length.

It is these facts that set bounds on how fast a person can read. It has been calculated that, even being very generous with the figures (reducing the duration of fixation to 200 ms; using the upper limit of how many letters we can see at one time), the upper limit for reading speed would be about 900 wpm.

How speed-reading works

This, then, is one of the things speed-reading programs aim to tackle - to increase the span of letters you can see in one fixation, and to alter the number of fixations. It is not, however, clear that (a) you can in fact train people to increase this span, or (b) it would be useful to do so.

What research does show, is that speed readers, while they don't change the length of their fixations, do significantly differ from normal readers in the *pattern* of their jumps. One researcher concluded from the pattern of eye movements, that speed-readers are in fact *skimming*.

Now there is certainly nothing wrong with skimming. Indeed, it is an extremely valuable skill, and if you wish to improve your skill at skimming, then it may well be worthwhile for you to use a speed-reading program to do so. On the other hand, there is no particular evidence that such programs do anything more than modestly improve your skimming skills.

Testing speed-reading skills

One study compared expert speed-readers against other groups of superior readers. While the speed-readers were fastest (444 words per minute - a respectable speed (250 wpm is average) but nowhere near the claims made by many of these programs), their comprehension was relatively low (71%). [1]

Interestingly, the speed-readers' speed was about twice that when they knew their speed was being tested but their comprehension would not be. In other words, like the rest of us, they slowed down markedly when they wanted to *understand* what they were reading (and what otherwise is the point of reading something?)

Well, actually, there is one circumstance when you read and do not look to understand or retain what you read - which brings us back to skimming.

So, how did our speed-readers compare on skimming skills? Two tasks were used to assess these:

- to pick the best title to passages presented at rates of 7500, 1500 and 300 wpm
- to write summaries of 6000-word passages presented at 24000, 6000, 1500 and 375 wpm

The speed readers were in fact no better than the other groups at picking titles, and though they were best at writing summaries when the passages were presented at 1500 wpm, they were no better than the others at the other rates of presentation. In an extra test of recall of important details, the speed readers in fact did worst.

Reading for understanding

Please don't mistake me, I am not condemning speed-reading - merely their often extravagant claims. Learning to skim (if you have not developed this skill on your own, and many have) is clearly worthwhile. Learning not to subvocalize - yes, I think there's value in that too. I cannot speak to any research, but I know from my own experience that when I am reading slowly, either because the material demands the effort or because I wish to make the book last longer, I make myself 'hear' the words in my head. Subvocalization does slow you down - if you wish to read faster that you can speak, you need to discard the habit.

And lastly, active reading. Well, that deserves a whole chapter of its own. So for now, for those who don't know what it means, I shall simply define it. Active reading is about *thinking* when you read. It is about asking yourself (and the book) questions. It is about anticipating what is going to be said, and relating what you read to what you already know, and making inferences about what you've read. Active reading is about understanding, and thus it is an essential part of reading to remember.

So that too, is a very useful skill.

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