Magical Number Seven

A sound base of knowledge is needed to overcome the limitations of working memory.

By E. D. Hirsch, Jr.

In the 1950's, George Miller wrote a famous article about the limitations of working memory called "The Magical Number Seven, Plus or Minus Two." The title was Miller's way of saying that the number of bits of information we can handle in the brief span of working memory is very limited — five to nine items at most.

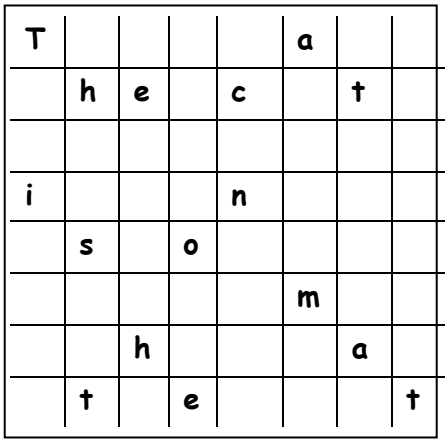
The acquiring of academic skills, including notably a big vocabulary, consists of building efficient mental systems that enable us, despite our very limited working area, to perform feats of analysis and synthesis.

A famous experiment conducted by Dutch psychologist Adrian de Groot illustrated this universal bottleneck in human processing skills. He noticed that chess grand masters have a remarkable skill that we amateurs cannot emulate. They can glance for five seconds at a complex mid-game chess position of 25 pieces, perform an intervening task of some sort, and then reconstruct the entire chess position on a blank chessboard without making any mistakes.

Performance on this task correlates almost perfectly with one's chess ranking. Grand masters make no mistakes, masters a very few, and amateurs can get just five or six pieces right. (Remember the magical number seven, plus or minus two.)

On a brilliant hunch, de Groot then performed the same experiment with 25 chess pieces in positions that, instead of being taken from an actual chess game, were placed just at random on the board. Under these new conditions, the performance of the three different groups — grand masters, masters, and novices — was exactly the same, each group remembering just five or six pieces correctly.

The experiment suggests the skill difference between a master reader who can easily reproduce the 16 letters of "the cat is on the mat" and a beginning reader who has trouble reproducing the same letters.



An easy-to-remember chess layout

If the 16 letters were "rtu kjs vb fw nqi pgf," the expert would exhibit little skill advantage over the novice; on average, neither will get more than a short sequence of the letters right.

Practised readers, chess grandmasters, and other experts do not possess any special mental equipment that novices lack, and they do not perform any better than novices on similar yet unfamiliar tasks. Nonetheless, experts are able to perform remarkable feats of memory with real-world situations such as mid-game chess positions and actual sentences. How do they manage?

The sentence "The cat is on the mat" consists of six words that are easily remembered. Expert readers can easily reproduce the 16 letters, not because the letters are individually remembered, but because they are reconstructed from previous knowledge of written English.

What de Groot found, and subsequent research has consistently confirmed, is that the difference in higher-order skill between a novice and an expert lies not in mental muscles but in what de Groot called "erudition," a vast store of available, relevant, previously-acquired knowledge.

Despite the narrow limitations of working memory, the wealth of contents that can be manipulated by experts through this previously-acquired erudition is immense.

If I already know a lot about baseball, the term "sacrifice fly" can summarize a page or two of exposition. Such shorthand representation is a chief time-saving technique of higher-order skills.

The phrase "World War II" is short and therefore easily remembered, but the content represented by the phrase cannot be grasped by those who, however skillful in other ways, lack that relevant knowledge.

I use these examples as a rapid way of indicating why an academic skill like reading depends on learning much more than the foundational ability to form sounds from symbols, turn the sounds into words, and put the words together in sentences.

While such formal skills are critically important, they are quite insufficient to comprehend a passage about World War II in the absence of relevant background knowledge. The skill of reading (and listening) depends on, among other things, a previous knowledge of what most of the words in a text mean and refer to.

De Groot showed that being an expert in chess does not improve one's memory for randomized chess positions. Tracing the implications of that discovery, psychologists have found that being a critical thinker in chess is not likely to improve one's skills in areas other than chess, like mathematical problem-solving or the ability to think logically about politics. This is one of the most solid findings in psychology, confirmed and reconfirmed many times.

The reason can be traced back to the bottleneck of working memory. The ability to solve any problem depends on having a specifically relevant and available vocabulary and body of knowledge.

(Adapted with permission from "Not So Grand a Strategy" in* Education Next, *Spring 2003. Dr. Hirsch is professor emeritus of English at the University of Virginia)