Speech at American Educational Research Association Convention, approx. 1968

Educational applications of mnemonic devices

Gordon H. Bower[1]

Stanford University

I will talk about mnemonic devices and their educational applications. Let me tell you how the talk will be organized. First, I'll claim that mnemonics are very effective learning aids -- I won't review much evidence there, but will give one result to illustrate the power of such methods. Second, I'll claim that rote learning is where mnemonics are most applicable, and I'll argue that education inevitably requires the learning of some rote materials. Third, I'll discuss a few mnemonic devices and the general class of tasks to which they're applicable. Fourth, I'll indicate how particular educational applications will require a good behavioral analysis of the learning task itself before one can construct viable mnemonics for it. Fifth and last, I'll mention some of the problems of applying mnemonics in practical educational settings.

To begin at my first point, let me say that there can now be no doubt that deliberate use of mnemonics helpschildren and adults to learn faster. To doubt that is to doubt God, country, and the value of motherhood. Many controlled laboratory studies have now shown impressive gains produced by mnemonics methods in various learning tasks -- in paired associates, serial ordering, free recall -- with both meaningful and meaningless or nonsense material.

The gains in learning can be spectacular in many instances, with quite large effects. I'll give just one example from our research, a study showing how memory is improved by having the person impose a unifying thematic organization upon the material. The experimental subject, a college student, was handed a list of 10 unrelated nouns and asked to learn them in serial order. He was told to do this by making up and weaving a

narrative story around these nouns using them in the correct order with these nouns serving as the main actors or actions in the narrative. This story construction usually took him about one to two minutes. The time he took was recorded and the same amount of time was given to a yoked control subject who was handed the same list of words and told to memorize them for serial recall, but he was not told to make up a story around the words. Both students were tested for recall immediately after the list was studied: this immediate recall was about perfect for both students, so there was no difficulty there. The difficulty stemmed from the fact that twelve different lists of words were studied successively by the subject one after another, all this within an interval of 30 to 40 minutes. At the end of that time, the subjects were tested for recall of each list by probing with the first word for recall of the remaining words in the list.

The results for the two conditions are shown in Figure 1 giving the percentage words recalled in the 12 lists by the Narrative-story subjects and by the Control subjects. You can see that there was a

- - - - - - - - - - - - - - -

Insert Figure 1 about here

- - - - - - - - - - - - - - -

tremendous effect due to the narrative-story construction. Recall averaged 94% for Narrative subjects versus 14% for Control subjects. With that kind of effect, one doesn't bother doing statistical tests. So in this specific instance, the mnemonic device increased recall by a factor of about 7, and those are the kinds of effects I'll be talking about.

Fig. 1. Median percentages of words recalled in correct serial order for the 12 successive lists (from Bower & Clark, 1969).

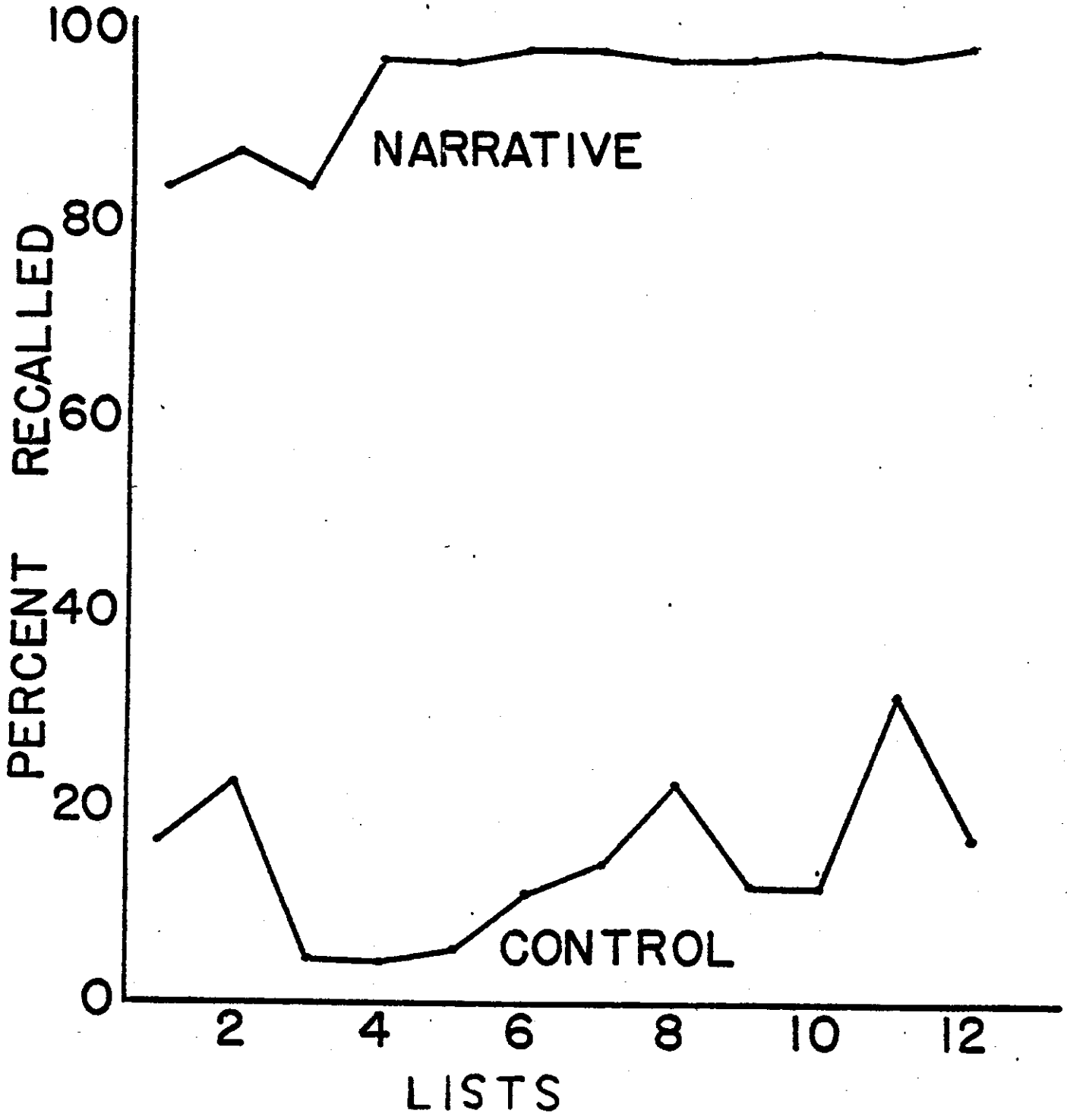


Figure 1 illustrates the magnitude of effects that can be produced by particular mnemonics. The illustration was for the learning of serial lists of unrelated words but the value of mnemonics has been demonstrated in other laboratory tasks. It's a fascinating job for the psychologist to try to figure out why specific mnemonics are so effective -- for example, why mental imagery is remembered so well. I do a lot of that kind of research, but it isn't of much relevance to the educational applications that concern us today. Most of the mnemonics demonstrations I know about have been with small amounts of artificial laboratory material, using compliant college students as subjects, observed over an hour or so of learning or retention. For obvious practical and economic reasons, there is no research that uses mnemonics with massive amounts of highly structured content material distributed over months -- say, material like that presented in a high school history or physics course. But I see no reason to doubt that mnemonics will be helpful in such situations for learning the more arbitrary or isolated components of structured materials.

You probably want to ask, "In what situations can mnemonic devices be helpful?" and the answer to this is the second main point of this talk. The general answer is that mnemonics are useful for improving memory of arbitrary associations or lists of arbitrary facts; they can also be useful for organizing familiar facts so as to make the whole set more accessible for perfect recall. These are, roughly speaking, rote learning situations. Despite protests to the contrary by teachers, I am impressed that rote learning constitutes a large percentage of what gets taught and learned in schools, particularly after basic reading, writing, and math are learned. We teachers are fond of denying that our students must rote memorize huge amounts of material in order to be certified as competent in our subject. Rather we state educational goals in terms of developing the student's

greater love for and appreciation of the subject matter, or developing his ability to make insightful criticisms, theoretical comparisons, arguments, and the like. By and large, that's a lot of high-sounding bunk -- at the very least, these are only extra requirements beyond the rote memorization of basic facts that we demand of our students. Any geography student who thinks Minneapolis is in France, or any art history student who thinks Salvador Dali painted the Sistine Chapel, is going to flunk his exams if he pulls such boners often enough. So we do demand a lot of memorization from our students.

We try to ease that burden by organizing or structuring the course content so that the student can comprehend new concepts and relationships between concepts, so he'll be able to subsume new facts or ideas under previously learned hierarchies, and the like. Such teaching efforts towards organizing material into comprehensible form are much to be desired, and most of our workaday school learning is of this kind that proceeds almost incidentally without conscious intent to memorize. But comprehension of structural relationships among highly organized concepts, as in some physical theories, still does not relieve the student from having to learn many arbitrary lists of facts, many unfamiliar words or concepts, lists of applications and how they're derived, and so on, all these arbitrary facts to be associated to the tightly knit conceptual structure of the theory. At the least, mnemonics can serve as retrieval aids for lists of arbitrary facts, making them readily accessible to recall.

So I've now claimed that mnemonics are effective, that they work with and seem especially appropriate for materials usually learned by rote methods, and that such materials exist in most educational curricula. My

third topic is to briefly characterize a few mnemonic techniques and indicate what they're good for, giving a relatively abstract characterization. Any good paperback book on 'How to improve your memory' will give a representative list of techniques. The word "mnemonics" refers to a grab-bag assortment of different procedures or methods for cognitive or imaginative elaboration of the materials to be learned with the purpose of helping the person to remember better. Different mnemonic methods are appropriate for different kinds of learning tasks, and some tasks require a combination of methods. The particular assortment of methods one finds in mnemonics books is a historical accident the character of which has been influenced by two specific factors: first, some mnemonics are purely for show business, for the stage performer: they make a spectacular performance, like rapidly memorizing a deck of playing cards, but one would be hard pressed to see the practical usefulness of the method; second, most mnemonics have been devised for solving the common memory problems which most of us encounter in everyday life -- how to remember names and faces, telephone numbers, addresses, appointments, errands, shopping lists, speeches, the plot of stories we've read or heard, and so forth. These are the sorts of problems brought to mnemonics teachers by their lay audiences; and their solutions to how to remember such materials are what get taught and written up in most books on 'How to Develop a Super-powered Memory'.

I'll touch briefly on just a few of the techniques. First are coding techniques; these are for learning numerical information by converting a meaningless number into a familiar and meaningful word. This system is useful for remembering numerical information like historical dates, economic data, population figures, ages of people, telephone numbers, street addresses,

and so on. A part of the system is illustrated in Table 1. The idea is for the person to first learn a list of digit-to-consonant sound substitutions,

- - - - - - - - - - - - - - -

Insert Table 1 about here

- - - - - - - - - - - - - - -

and then he uses this list to substitute a string of consonants for a string of digits. The consonants are then to be augmented by inserting vowels to make a meaningful word, and then the person is to remember the word by some technique or other. For example, one can remember that World War I began in 1914 because when the war started, all tours to Europe stopped. The key word here is tours; it has the critical consonants t, which stands for the digit 1, and r, which stands for 4, so that tours converts into 14, so one recovers the fact that the war started in 1914. That's the sort of thing one can do with the procedure. Of course, to be efficient, the person has to practice the code until he becomes reasonably skilled, much like a Morse code telegrapher, but it pays off when one considers that we are constantly inundated with numerical information which we'd like to remember like the date of this meeting or what hotel room we're staying in.

A second set of mnemonics is useful for doing associative learning, where several units are to be associated with one another. This includes arbitrary listings that have to be learned -- for example, the color-code for electrical resistors, the periodic table of chemistry, the principal products of Brazil, or English equivalents of foreign language vocabulary items. It also includes less rote appearing things like learning definitions of new concepts, extending the list of semantic features we know about a familiar concept, relating concepts, and associating subjects to predicates in sentences. Generally speaking, the prescription is to search for a familiar relation between the several items that are to be associated,

trying to assimilate the new connection to things known before.

Figure 2 tries to simplify and summarize a vast number of things that can be done here depending on the materials A and B that are to be associated

- - - - - - - - - - - - - - -

Insert Figure 2 about here

- - - - - - - - - - - - - - -

and the relations possible between A and B. These associating strategies include things like construction of mental imagery of some interaction between A and B, or viewing A and B as parts of a perceptual or conceptual unity, or finding a relation between A and B, or finding an intermediator term that is easily related to and suggested by item A and which readily suggests item B. Each of these possible mediation routes has been studied by psychologists in very many experiments, so a lot is known here. The appropriate elaboration strategy here depends on the type of materials but I'll spare you all the messy details.

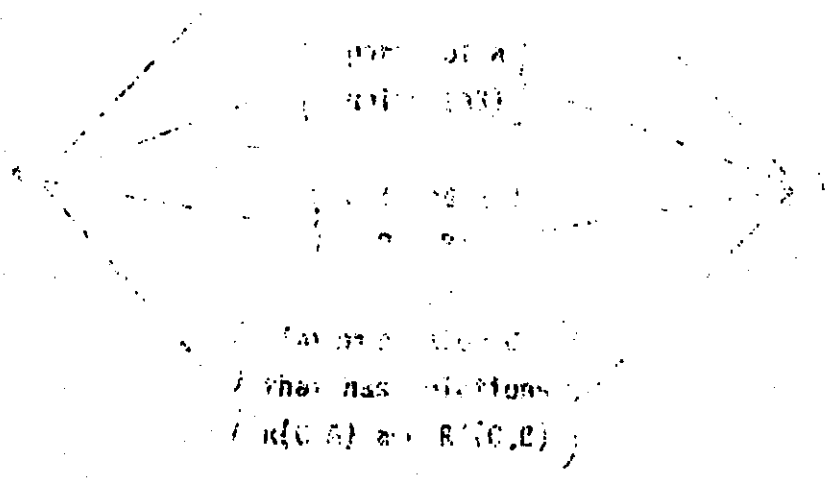
Another mnemonic is the peqword system which is a scheme for cuing recall of arbitrary lists of facts regardless of how unrelated they may be. The problem in freely recalling a large set of items is to provide oneself with cues or reminders of all the items. Peqword schemes solve this problem by having the learner use a well-known list of cues as the conceptual pegs upon which he hooks the successive items that are to be recalled. The scheme is illustrated in Table 2, showing the first few pegs, 1-is-a-gun, 2-is-a-shoe, etc. The first item is hooked to the first peg by the person

- - - - - - - - - - - - - - -

Insert Table 2 about here

- - - - - - - - - - - - - - -

constructing an imaginary scene of interaction between gun and the first



item, and he does likewise with the later items. When recall is requested, the person can run through his well-known peg list, call to mind the imaginary scene he constructed around each peg, recognize and then recall the other item represented in that imaginal scene. This system works quite well in boosting free recall, and it has been validated in several instances with actual school-learning materials, like geographic facts about a country. The scheme also provides serial order information. Such pegword systems are useful for learning arbitrary lists of things -- for example, the order of presidents of the United States, the 50 states and their capital cities, sequences of significant historical events, a listing of the various laws of visual perception, the list of defining criteria of mammals, and so on. It's good for practically any arbitrary list where the items are in some sense already familiar and meaningful to the person and his main problem is one of getting ready and reliable access to what he knows.

Other ordering schemes exist, such as the narrative chaining method we used in that experiment I talked about before or the use of especially coined words or coined sentences to remember the serial order of familiar items -- like the "On Old Olympus' Towering Tops..." limerick for cuing recall of the twelve cranial nerves. But I've given enough of a sketch so you can get the idea of what mnemonics are about.

One can combine several devices to perform ingenious tricks, of course. An acquaintance of mine, a 96-year old gent, can memorize perfectly a new list of 50 three digit numbers given to him at the rate of one every 5 or 10 seconds; he'll recall them perfectly and also be able to say which number was the twenty-third, and that 749 was the twelfth item you gave him. How does he achieve such astounding feats? By a combination of the pegword system and the number-to-word coding system. He has concrete images associated as pegs

to each of the first 50 integers; he also has a coded conversion-word for each of the first 1000 numbers; so he simply forms mental images between the N^{th} pegword and the word code corresponding to the N^{th} 3-digit number you've given him. Thus, if the third number in the list is 342, his peg number is TREE, his code for 342 is MORON, so he images a moron sitting up in the branches of a tree.

You may say, well fine, that stuff's all well and good for stage freaks or exhibitionists, but what good will it do in an educational setting? I'm convinced mnemonics can do a lot of good in increasing learning and retention of educational materials with children or adults. That doesn't amount to much of a claim because I suspect that current methods for teaching rote materials in the schools are haphazard and stress simple repetition and drill, and I know we can beat that in many instances.

Let us consider how mnemonics might be implemented in educational settings. There are basically two approaches, as I see it. The cheap way is just to give each child or student one or more methods courses on how to memorize, tailoring it to his level and showing applications to materials of current relevance to his education and to his life situation. This is in effect the Dale Carnegie sort of course that is currently given to lay audiences by commercial memory experts, and they are undeniably effective in many instances. There could be recurrent instruction and training in mnemonics techniques throughout a child's school career. However, this approach is likely to lead to mediocre results in many instances, because the program does not ensure that the appropriate cognitive behaviors occur in the natural classroom setting away from the mnemonics-methods course. Much like speed-reading techniques, a mnemonic techniques is of no use unless it's applied, and it's likely that many students would have to be shown

repeatedly how to apply mnemonics to each of their lessons.

The second plan would be to attack on two fronts at onee -- teach students the general methods as before but also have the texts and the teachers programmed to provide content material with a liberal infusion of mnemonics to help the student remember the content. That involves several things, like convincing teachers that they should attend to such matters, and developing texts and supplementary materials written with the aim of not only presenting the content material but with due attention to presenting mnemonics to help the student remember the material. Developing a mnemonics-infused content text would involve several sorts of issues.

First, one would need a clear conception of exactly what is worth remembering in the course, so one can decide what the student has to remember. For example, does each subdivision or unit of information have to be ordered, can it be grouped and hierarchically organized in some special way, need it be remembered verbatim or is just the gist of the propositions sufficient, can the ideas or relations be represented pictorially, and so on.

Second, one would need a fairly good knowledge of what the student already knows, since most mnemonics relate the unknown new material to the known old material. To use a currently popular term, what the mnemonics-oriented textbook writer needs is a pretty thorough "task analysis".

Third, and finally, he needs a large amount of creative imagination to make up mnemonics that fit the material at issue. Making up a mnemonic is like solving a problem, namely, finding and displaying comprehensible relationships between the familiar things someone knows and the new material he is to learn. For this reason, making up a good mnemonic has many of the features of theorem proving, namely, to construct a path relating one set of known or given statements to another set of unknown statements.

That takes some imagination and it would be time consuming to do that for a whole course or textbook, but it would be no more so than the development of most programmed textbooks.

In any event, if one were to go this route, he might first mount a mnemonics attack on a particular course content, writing a sort of textbook for how to remember that specific material. A lesser goal would be to seek more substantial experimental validation of teaching by mnemonics; this could be done with a smaller amount of content material, say a chapter of a biology or history text, or a couple of brief 1-2 page texts. These lesser materials, that can be made up in a matter of days, are much preferred by researchers, as opposed to testing with materials that may take months or years to develop.

Let me mention just a few more of the problems of applying mnemonics in educational settings. First, for some materials it is simply difficult to think up mnemonics to ease their learning, and we should just learn to live with that, until an appropriately ingenious person shows us how to do it.

Second, we do not know the long-term effect of massive use of mnemonics by a student: for example, mnemonics may appear effective in laboratory experiments because they are rather distinctive and interesting curiosities for our educationally jaded subjects, but such techniques might begin to lose their unique effectiveness when they are being used over and over for learning most things. I mention this as a possibility, though I consider it very improbable, judging from the daily performance of memory experts I know who've been using the systems for years.

Third, it is possible that whether mnemonic method A or B is better for remembering some given material depends on individual characteristics of the learner. I think this is doubtless true for certain obvious variables like mental age; an intelligent college student may show differential success

with methods A vs. C whereas a retarded 4-year old child may not have the basic cognitive skills or equipment needed in order to implement the methods effectively. In this respect, it is helpful for the educational mnemonist to have comparisons of mnemonic techniques across mental ages of the sort provided by Joan Bean's study cited by Rohwer. What I definitely wish to prevent, however, is the public's common interpretation, that since the methods' effectiveness varies with the person, then there's nothing to be done short of very expensive tailoring of an educational program for each student. That is surely the counsel of despair, is just as surely false, and it must be rejected if educational innovation is to proceed.

Fourth, in introducing menmonics into an on-going curriculum, one is likely to meet some initial social resistance from teachers or from students -- either because they don't want to admit that one should ever memorize anything, or because they are not convinced that mnemonics will work, so they will not use them. Like many things, mnemonic techniques are easy to parody and poke fun at. But that makes them none the less effective when they're used, and there's nothing like success to reinforce someone in a new method of learning. Critics rarely make explicit what is the alternative to conscious attempts to cognitively elaborate the material so as to memorize it: the unspoken alternatives are usually dumb, blind repetition, or simply outright failure, and no one seems to want to champion those alternatives.

I've mentioned some general difficulties in applying mnemonics in educational settings, but I do not intend to dash cold water on attempts at such applications. Quite the contrary, I think these applications should proceed with all deliberate speed. In my opinion, the educational potential of applying mnemonics is about as great today as was the potential of programmed instruction 15 years ago. In other words, I'm convinced there's much educational gold in these hills.