Memory: Old News, Bad News, New News, Good News

Earl W. Stevick
Lexington, Virginia

1. Introduction

For quite a few years now, I've been exploring one aspect of the created order: the way human beings learn new languages. I've been exploring first of all for my own interest, but also for the interest of anyone who cares to look over my shoulder. As part of this project, I once wrote a book called *Memory, Meaning, and Method* (Stevick, 1976). Now recently, sixteen years later, I've been trying to update—or actually, to replace—the chapters on memory. Needless to say this has required a lot of reading and a lot of head-scratching. What I'd like to do today is to share with you some of my preliminary results—the reformulations and the replacements that I'm working with right now.

The big question—the question within which all other questions are only details—has been "What do we know about human memory that can help language teachers to understand their work better?" And I'm using the word "memory" in as nontechnical a way as I know how. "Memory," to me, is just a label for the observations—the formal and scientific observations as well as the informal observations—that people are able to hold onto and to profit from.

I'd also like to use the word "information" in a nontechnical way. In everyday English, "information" means simply the difference between one thing and another. Items of information are of many kinds and many sizes: the difference between night and day, the difference between three and four, the difference between seeing that something worked and seeing that it didn't work, the difference between /l/ and /r/, and so on.

2. Memory: The Old News

Some of what I wrote about memory in 1976 was news to me, and was apparently news to a number of other people as well. Looking back on the first three chapters of *Memory, Meaning and Method*, I see four main points:

1. Memory consists of—or memory is supported by—physical changes in the brain.
2. There is a distinction between "short-term memory" (STM) and "long-term memory" (LTM).

3. Whether or not a new piece of information gets through STM into LTM depends partially on what happens to it while it is in STM.
4. In particular, processing in STM, and resulting storage in LTM, takes place at one or another "level" along a dimension of "depth."

This was my news about memory in 1976, and I thought that overall it was pretty good news. In 1993, of course, it's old news.

Now, seventeen years later, as I look back at this old news, think it may have indeed been good news for the styles of language teaching with which we were most familiar in those days. Those were the days when language study was just that—the study of language one part at a time. Exactly what those parts were, of course, varied from one method to another: they might be lists of words, or they might be tables of inflected forms, or rules, or memorized sentences, or structural devices to be automatically controlled, and the like. Those were the days when interactive, communicative, cooperative styles of language education, with language flowing *with* and *from* ongoing shared, meaningful, purposive activities, instead of being laboriously exemplified *in* activities, were just beginning to come into their own, and when the Input Hypothesis was only a gleam in Steve Krashen's eye.

Just notice the parallelism in how we looked at language and language teaching and at memory. Language for most of us then was made up of a sequence of well-defined items, items that the learner met one at a time. Similarly, teaching methods consisted of sequences of well-defined steps, to be followed one at a time. And my model of memory consisted of a series of clearly-defined entities (STM, LTM, etc.) operating in a clearly-marked sequence—operating on the clearly-delineated, countable words and ideas and structures of linguistic texts. I like to think that *Memory, Meaning and Method* helped some teachers toward a clearer understanding of the things they were doing in those methods, and may even have given them a few ideas about how to do those things better. But. . . .

3. Memory: The Bad News about the Old News

In the light of current research, the first of my four points—the point about the physical aspects of memory—still stands. That was of course the least surprising of the four, but it was also the one that led to the fewest practical consequences for language teachers.

Unfortunately, however, the other three points are pretty much in need of replacement. The second point—the one about STM as contrasted with LTM—is in the eyes of many cognitive scientists today both oversimplified

and wrongly focused (Klatzky, 1984), and my third and fourth points depended on it. The fourth point particularly—the point about the "dimension of depth"—was all right as far as it went, and I do think that it led to a few valuable suggestions for teachers, but again it was oversimplified and overly general (Bransford, 1979, pp. 65-68).

4. Memory: The New News

Which brings us to some new news about memory. I'm afraid that for now I can only list the main conclusions for you. The point that underlies just about all the rest is that I've decided to go along with those who talk, not about STM, but about "working memory" (WM). (For a readable summary of arguments, see Klatzky, 1984.) These are admittedly very closely related concepts. The difference is that STM is often thought of as a place, or as a stage, through which information must go in a unidirectional flow from the senses and toward LTM. By contrast, WM is not a stage, but a state—a state in which a given item of information may or may not be at any one time.

I'm also going to use the term "existing resources" (ER) rather than LTM. I'm doing so because the phrase LTM unfortunately has been used in two overlapping and potentially confusing ways. The first is a narrow technical sense which refers to information which is available a few minutes or perhaps an hour after it was presented, even though it may not be available a week later or a year later. Information that is available even after long periods of time has often been said to be in "permanent memory" (PM). Unfortunately, LTM is also sometimes used to include both LTM in the more restricted sense, and sometimes to cover a combination of PM and LTM. That's why I've made up the new term.

Now, there are certain advantages to each of these two, to WM and to the ER, certain things we can do with each of them, and there are also certain limitations to each. Let's look first at four nice things about WM.

The first and most conspicuous thing we can do with WM is to hold onto things without trying. In an everyday example, if someone tells us a phone number while we are busy addressing an envelope, we can often go ahead and finish writing the address, and then "play back" the spoken telephone number in our heads without difficulty. The same ability is being used whenever a language student repeats a word or a sentence that someone else has said a few seconds earlier. Second, as we or our students do play things back in WM, we can consciously notice things about them. Third, noticing two or more things that are in WM at the same time allows us to compare them with each other. Fourth, all this noticing and comparing allows us to do things with the contents

of WM intentionally: We can repeat them, we can arrange them in new combinations, send to the ER to see what else we know about them, and the like. This is where we apply what many writers these days are calling "strategies."

But there are also four negative points about WM, the first of which is that it has no permanent content. It's like a worktable; it's not like a filing cabinet. Second, things stay in WM only briefly; the usual estimate for auditory material is about 20 seconds. Third, the capacity of WM—the number of things that can be in this state at any one time—is quite limited. And fourth, some of this limited capacity of WM can be preempted by cognitive by-products of affective states such as anxiety. (This last is probably a lot of what the widely-used term "affective filter" is about.)

Now let's turn and take a careful look at the ER. There are ten positive things to remember about them:

1. We can hold things in the ER for a long time, even indefinitely. Everybody knows this, of course.
2. There is no known limit on how much we can hold in the ER. This too is a commonplace.
3. The ER can hold an almost unimaginable variety of kinds of information. We can think first of sensory information—visual, auditory, and so forth. But there are others, there are less obvious kinds of information, some of which are also extremely important for the overall working of memory. One of these "other" kinds of information is time: How long ago did I experience this? How frequent has this been in my experience? and the like. Of very practical importance to teachers is the fact that these "other" kinds of items include the metabolic changes (Hamilton, 1983) that go with fatigue, excitement, anxiety, and so forth. And all of these—the by-products of emotion along with the more conventional visual and auditory information and all the rest—can all be recorded in association with one another. This is another part of "the effect of affect" that language teachers sometimes talk about.
4. All of these kinds of information, and more, can become linked or connected with one another through associative bonds. The result is the formation of associative networks—networks that are products of what has happened to us, and that are different for every individual. We hear a lot about networks these days (Johnson, 1991;

Kail et al., 1984, p. 46; McLaughlin, 1990, p. 624; Perrig & Perrig, 1988, p. 102; Thompson, 1986, p. 946).

5. What is in the ER is not only varied in kind, and not only somehow tied together. It's also organized into various kinds of hierarchies. Actually, this word "hierarchy" is used from time to time in a number of different valid senses in writings about memory (Klatzky, 1984, p. 16ff.).
6. The items in the ER are not just either there or not there. It's a continuum (Sampson, 1987). Each item of information is, at any given moment, at one or another level of "activation" (Anderson, 1984; Mozer, 1983, p. 544). This is a point that writers in our field seldom mention.
7. The level of activation of a given item in the ER can increase, yet without reaching the level where it will register back in WM.
8. The connections among these items of information are also not just all-or-none. That is, it means very little to say that there "is" a connection between item A and item B of information. What we have to say is that there is a relatively strong connection between A and B. What this means is that a change in the level of activation of item A is likely to lead to a relatively large change in the level of activation of item B.

   Here is another continuum that is seldom mentioned in our field. On the other hand, this same concept of "spreading activation" among items or units is very widely cited in memory studies these days (Graf, Squire, & Mandler, 1984; Klatzky, 1985, p. 18; Nelson & Schmid, 1989, p. 539; Sampson, 1987; Johnson, 1991).
9. This spreading of activation from one item to other items to still other items within the ER is not quite instantaneous; each step does take a certain amount of clock time, but that amount of time is measured in thousandths of a second.
10. Last, the spreading of activation is an automatic process; it goes on by itself, and it goes on without conscious control. This means that the spreading of activation within the ER creates responses, but that the activity of creating those responses does not use up limited capacity the way activity in WM uses it up. (For a helpful treatment of capacity limits as they affect language learning, see McLaughlin, 1987, Ch. 6.)

The ER also have two very important limitations. One is that we cannot explore them consciously. The other is that we cannot change them directly.

So these are the main points about WM and the ER. What I'd like to do now is to look with you at how WM and the ER interact with each other, and at some of the wonderful ways in which the strengths of one compensate for the weaknesses of the other in the living of life in general, and also in the learning of languages.

The basic interaction between WM and the ER is query and response. That is to say, something that is presently in WM somehow contributes to the activation of one or more items in the ER. The increased activation of these items in the ER contributes to the activation of still other items in the ER, and so on automatically, until a reply is created. This reply now becomes part of the contents of WM, and this new item in WM—an item that has just come from the ER—can in turn affect the activation of further items back in the ER. So there's a continual two-way exchange. But the new item can itself also be acted on in WM within the limited capacity of WM—acted on by non-automatic, conscious, deliberate, intentional processes, including what many people these days call "strategies." The fact that material from inside the person and material from outside can and do compete with each other for the limited capacity of WM fits much more readily with the concept of WM as a state, than it does with STM as a stage. One result is that, to paraphrase Michael Halliday's paper at the 1992 Georgetown Round Table, the structure of memory is always in transition, because every act of recall, and even every act of recognition, transforms it, however microscopically, from what it was into something else.

Quantitatively, the length of time it takes to send a stimulus from WM to the ER and to get back some sort of reply or response is a very, very tiny fraction of the time that things can stay in WM—perhaps 1% or 2% by some estimates. This means that once an item has reached WM, a lot of work can be done on it, with it, and from it while it is still in WM. This large ratio between how long we have something available in WM and how long it takes us to get the reactions of the ER to that something is "an important element in complex cognitive operations" (Klatzky, 1984, p. 29).

Even recognition can become a complex operation, depending on the circumstances. A learner of Japanese, for example, who hears the words *tsugoi yokatta nee*, may have to go through three round trips from WM to the ER and back: (a) Have I heard these words before? Yes. (b) When, and in what context? Last week, in a discussion of popular music. (c) What did they mean

in that context? They meant something like "exciting." Such queries and replies can be time-consuming and, as the cognitive scientists would say, they can be capacity-depleting. From the learner's point of view, this identification process distracts attention from whatever input is being presented while this process of identification is going on. Again, the concept of WM as a state reflects this fact more clearly than does the concept of STM as a stage in a unidirectional flow.

My next point is another that we hear about seldom if ever in our field, but it's fairly well documented in research. This is that one and the same query from WM may produce two or more responses from the ER. For example, Bradley and Thomson (1984) observed a number of patients who suffered from one or another form of dyslexia, and they found three quite different routes by which a person can perform the task of pronouncing words off a page:

1. By one of these routes, which Bradley and Thomson (1984) called the lexical-semantic route, the ER generate a *meaning* that goes with the overall graphemic representation of the word, and then they generate a *pronunciation* that goes with that meaning.
2. By a second route, the ER respond to the overall graphemic shape of the word and generate a *pronunciation* for it without any dependence on meaning.
3. By the third route, the ER respond to *one grapheme at a time*, generating a *pronunciation* for it and in this way piecing together a pronunciation for the whole word.

All three of these outputs can show up in WM, one after another but still well within the time span that will allow WM to deal with them together. In normal readers, the three replies almost always agree, so there's no problem. But in those cases where the replies don't agree, WM compares them and notes any discrepancies. Then some of its limited resources are briefly devoted to choosing which of the replies to accept. This of course will entail further inquiries to and responses from the ER.

For the sake of reference in later parts of this paper, I'd like to refer to these routes as "coterminous pathways" (CPs). In plain English, CPs are two or more different ways of getting from the same input to the same output, more or less at the same time. (See Bub & Kertesz, 1982; Logan & Stadler, 1991, p. 495.)

In recent years we've heard a lot about something called "monitoring," first from Labov (1972, p. 79), and later, in a somewhat different sense, from Krashen (1977). In either sense, I'm fairly sure that "monitoring" is really a special case of what I've just been talking about: of generating two or more responses automatically in the ER, then in WM comparing these responses, and then choosing between them. In ESL, for example, one and the same non-native speaker could generate versions of Jespersen's (1904) famous sentence "We are not here" by some combination of at least three pathways:

1. It could be retrieved as a whole from earlier memorization ("We are not here.").
2. It could be a word-for-word translation from the speaker's first language ("We no here.").
3. It could be generated by reference to rules: rules for when to use the copula, rules for which form of the copula to use with which subjects, rules for how to negate, and so forth ("We no are here," following some but not all of the rules needed).

The last of these—the use of rules—would probably take longer to generate than the other two, particularly if the speaker had to consult several rules, but it would still reach WM in plenty of time to be compared with the other two pathways. And here we have Krashen's three conditions for "Monitor use": focus on form, knowledge of relevant rules, and time. But of course the same general process can account for numerous other kinds of decisions and self-corrections, both in linguistic form and in other kinds of behavior. And this, according to the view that I'm presenting to you today, is where we get the basis for all we do, whether it's speaking or tying our shoes or driving a car. We get our bases for action from the interaction of WM and the ER.

There's only one more point that I need to address, and that is how the networks get changed—the networks of associative bonds that make up the ER. In other words, how does learning take place? But remember that a change in a network usually means a change in the strength of an existing connection, and not the formation of a new connection. So the question of learning really becomes a question of how the strengths of these existing connections get modified.

In 1949, the Canadian psychologist Donald Hebb speculated that two neurons that tend to be active at the same time will automatically modify the connections (the synapses) between them. (For a summary, of this and related research, see Johnson, 1991.) In more recent years, Hebb's guess has been

confirmed by laboratory research. Now, no one has any clear idea about exactly how the physical nets of neurons in the brain are related to the conceptual networks of information in memory. All we can say for sure is that it must be terribly, terribly complicated. But let's assume, just for today, that there is such a relationship, and that Hebb's synapses do somehow figure in language learning. If that is true, then bonds will be strengthened and networks modified, and learning will take place, if at the same time in WM there are two things. The first of these two things is a record of some action—a physical or a mental action. This record must include not only the nature of the action; it must also include a record of means—of how that action was arrived at (Rabinowitz, 1990), and it must include the purposes of the action. And the second thing that must be in WM at the same time is knowledge of results.

If the results at least partially match the purposes of the action, then the connection between purpose and means is strengthened. Sometimes, this knowledge of results comes from outside; then we say that the learner's action has been "reinforced." At other times, we find that one of a pair of CPs has led to the same output as another, a better-established pathway, has led to; in this case the second pathway acts as a sort of internal reinforcer for the first, and we say that spontaneous learning has taken place.

So let me just highlight for you three of the differences between this view of learning and memory (the "New News") and the folk view which is found in *Memory, Meaning, and Method*, and which is still implied in much of what language teachers have written from time to time.

First, the nature of remembering. In the usual view, a word or a structure or a meaning or whatever is either retained and retrieved or it's not retained and retrieved. In the view I've outlined for you today, things are not so much retained in and retrieved from memory as they are reconstructed. Moreover, ease and speed and accuracy of construction vary along a continuum.

Second, the nature of what is remembered. In one view, focus is mostly on the visual and auditory modalities. Forms are made up of listable vowels and consonants or rules or whatever, and meanings are the kinds of things that could be described in words, perhaps in a dictionary. In the other view, the items involved in memory are quite varied, both in nature and in size.

And third, the process of memory. I think the usual unspoken assumption can be described as a unidirectional flow: some of the data that come in through the senses get into STM; some of what has gotten into STM moves on into LTM; and some of what is in LTM somehow becomes output when it's needed. Contrast this with the idea of WM and the ER in constant interaction

with each other, operating with reciprocity and recursiveness rather than with linearity, where WM is as much involved in the process of production as it is involved in the process of storage.

5. Memory: The Good News

The good news about this new news is that it seems to fit a lot better into some of the things we are learning about language learning. I've already mentioned the so-called "affective filter" and "monitoring," which are two concepts commonly associated with Krashen and Terrell's Natural Approach (Krashen & Terrell, 1983).

Another phenomenon that I think the new news helps us to understand better is the so-called "generation effect" (Gardiner & Java, 1990; Slamecka & Graf, 1978; Wall & Routowicz, 1987). I said a little about the generation effect in my article (Stevick, 1992) in the September issue of *The Language Teacher*, which some of you may have seen. Briefly, the generation effect is an observation that people are more likely to remember things they made up themselves than they are to remember things that they've only read or heard from someone else. I think the concept of WM as a state, and the concept of spreading activation among many kinds of tiny bits of information within the ER, are very useful in this regard.

The example that I would like to spend our last few minutes on is the so-called "distributed practice effect" (Stevick, 1976, pp. 28, 77). This phrase, the "distributed practice effect," stands for the observation that in general it's more efficient to study a given thing on several different occasions, than it is to study the same thing the same number of times all together on a single occasion. The distributed practice effect is, as the experimenters like to say, "robust," by which they mean that it has been documented for quite a wide variety of tasks, and under a wide range of circumstances.

In my article in the September Language Teacher, I used as an example the Turkish word *tamam*, which means "complete(ness)." Let's suppose today that this time, unlike the example in *The Language Teacher*, a learner's goal is to move from the declarative knowledge that "English 'complete' is *tamam* in Turkish," and to the procedural knowledge which will bring the Turkish vowels and consonants to WM immediately after the meaning "complete" shows up in WM, rather than requiring the learner to resort again and again to whatever mnemonic he or she had pieced together by the Keyword Method.

A learner who was doing massed practice might on some one occasion repeat the word and its meaning ten times mechanically, using and strengthening

that maximally simple, two-ended associative bond that I mentioned a few minutes ago. Or the learner might go ten times in a row through the Keyword mnemonic that I described in the article, with its four-cornered network of CPs. Or the learner might repeat ten times a personally meaningful sentence containing *tamam*. The important thing is that whichever of these things—simple or more sophisticated—whichever is practiced ten times in a row, that's all that's being strengthened in the ER. So there's no real opportunity for the brain to determine which items of information *regularly* go together ("semantic memory") and which just *happened* to go in some one context on same one occasion ("episodic memory") (see for example Bransford, 1979).

Doing distributed practice, on the other hand, the same learner might do exactly the same kinds of things I've just listed, but on five or ten different occasions. Under these circumstances, the networks that got strengthened in the ER would differ among themselves at least with respect to their information about time. Quite probably various changes in the context would eliminate same other kinds of incidental and nonessential information as well. This would be one very rudimentary advantage of distributed practice over massed practice.

There is, however, a second advantage. This second advantage is more subtle, but I suspect it may be more important. That is what happens at repetitions two through 10. On repetition two (that is, the second time the learner meets the idea of "complete" and tries to supply the corresponding Turkish word), the ER typically are unable to come up with a reply that's complete enough to be usable for output. There is, however, a lot of interesting research evidence that the ER do at least produce a partial reply; that is, that they produce some though not all of the items that would be needed for a complete and usable reply (see for example Kozlowski, 1977; Reason, 1984; Reason & Lucas, 1984). For example, maybe on the second presentation the learner's ER can produce only the facts that the word began with *t* and that it had two syllables. And when these two items, together with the query "complete," and also together with the answer from the other side of the vocabulary card or wherever, are present together, then the process that constructed the partial answer is reinforced by its agreement with the representation of the right answer, and so next time it will be quicker, and it will use up less of the limited capacity of WM.

Well, we've come to the end of our time today. In this very brief period, I've tried to sketch for you a view of memory that is both recent and, I think, more adequate for our needs in language teaching than the view most of us have

been accustomed to, and I think this is true both with respect to theory and with respect to practice. With respect to theory, I've said that I think this view gives us a better account of the generation effect, the distributed practice effect, affective filtering, and monitoring. And these same theoretical concepts—the generation effect, the distributed practice effect, affective filtering, and monitoring—are much more important, much more conspicuous nowadays in communicative teaching, in group-centered, cooperative learning, even in some versions of computer-assisted language study, than they were in most traditions that preceded our contemporary practice.

Thank you for allowing me to share with you my ongoing attempt to understand better this enterprise in which all of us, in our countless different settings, are responsibly engaged. (And I look forward to comments on the printed version of this paper!)

Earl W. Stevick, formerly Professor of Linguistics at the Foreign Service Institute, has also taught at the American University and Georgetown University. His books include: *Memory, Meaning, and Method* (1976), *Teaching Languages: A Way and Ways* (1980), and *Humanism in Language Teaching* (1990). He was a Main Speaker at the JALT '92 Conference, where he delivered this plenary address.

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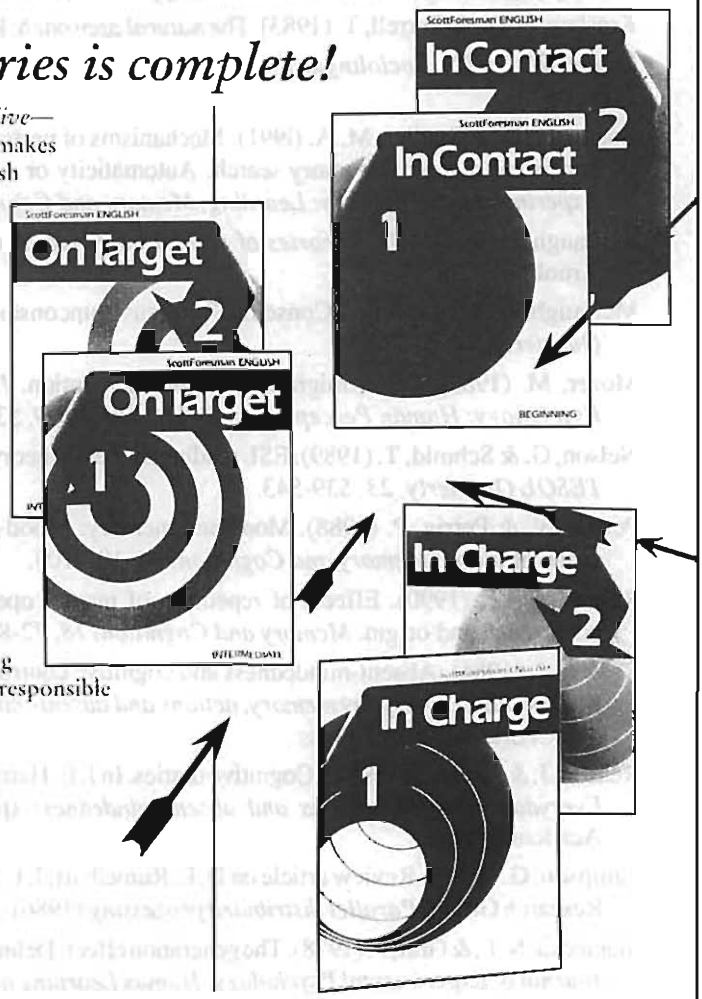

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