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The Evolution of CALL

Computer Assisted Language Learning (CALL) is an emerging force in language education. Despite its awkward beginning and the on-going resistance of many in the language teaching community, it is maturing and showing that it can be a powerful tool in the hands of experienced teachers.

In its early days, CALL was driven by technology and technologists. Proponents of CALL tended to focus on the "Computer Assisted" portion of the acronym rather than the "Language Learning" portion. Technology seemed to offer solutions that could be plugged-in and delivered through a box and game-like interactions. Learning would be fun and relatively effortless, and the role of teachers would diminish.

However, technical limitations and the lack of a reliable delivery and support infrastructure led to an adventurous but unstable environment where much money was wasted. Institutions invested in systems that were either underutilized or were used in ways that had little if any benefit for education other than to keep students occupied and labs appearing to be modern. As for teachers, they were seldom consulted or provided with training, partly because there were few in academia with relevant experience and partly because teachers, with justification, regarded CALL with scepticism and fear. There was an implicit belief that teachers and CALL were competing for the same role -- CALL versus classroom-only -- rather than in a partnership where each approach "assisted" the other.

What was missed by many was the recognition that the most effective use of technology is not just to do old things in new ways. Rather, the real opportunity was to examine how the new tools of technology had broken through the page and text barrier, allowing the development of a new range of listening-based interactions. This created theoretical opportunities for fundamental changes in language learning, including a rethinking of the relationship between the four skills and the learning synergies between them. What was needed was a learning theory and a model to *guide* the application of technology.

Multi-Modal Learning

Recent research in the neural sciences has provided many insights into how learning takes place and how language learning may be optimized. In particular, it supports the view that multimedia exercises can be designed to take advantage of how neural processes work together in the learning process. Figure 1, for example, is an

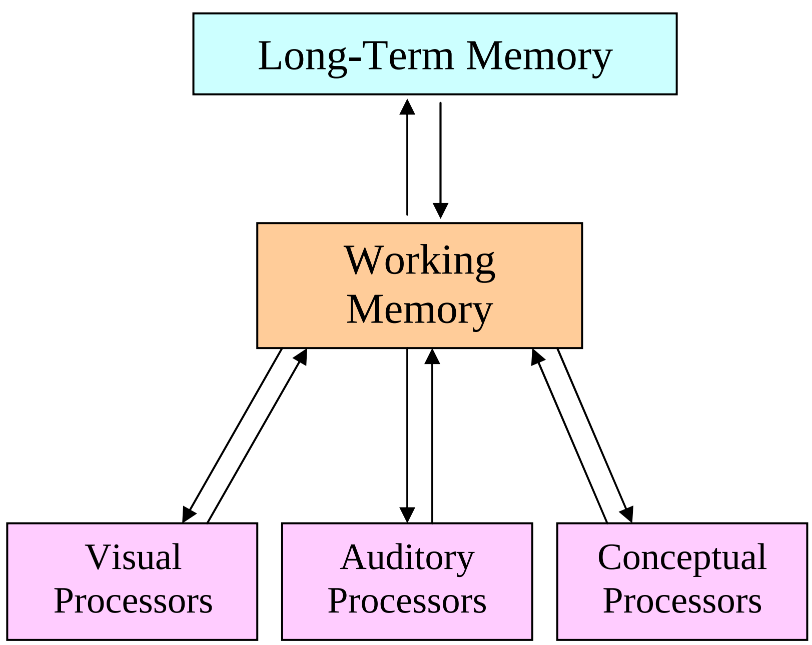

Figure 1

oversimplified diagram that shows how various processors in the brain communicate with the *working memory*, which is instrumental in the learning process. The key point in the figure is that multiple processors, such as the visual, auditory, conceptual, phonological, orthographic, and many others, are involved and can be activated in well-designed activities. Research shows that these processors work in parallel in the unconscious and interact with the working memory and long-term memory to piece together and interpret language -- along with the sensory input that accompanies and supports language.

Neuropsychologist Donald Hebb was one of the first to hypothesize that learning involves the alteration of neural connections. His ideas are often summarized by the phrase: “neurons that fire together wire together,” and this is just what CALL allows and promotes. For language learning, a key element is the *synchronized* activation of the auditory, phonological, and visual systems in the brain, especially important for listening and reading development. These distinct systems work together with grammatical and conceptual processors to decode sensory input into meaningful language. Damage to any one of them, or the connections between them, can severely limit the ability to learn one or all of the language skills.

Laboratory research has revealed that much of this sensory and language processing is extremely fast, especially for listening and speaking skills, and is beyond conscious control. There is simply no time to reflect on or search for rules when one is listening. Automaticity is required, and this kind of skill learning requires practice of a kind that has not been provided in sufficient quantity or quality by textbook-based instruction.

Practice Makes Perfect

The neurolinguist Steven Pinker says that competence comes from practice, and automaticity comes with *copious* practice. When learning to read, Pinker says, children need practice at connecting letters to sounds, not just immersion in a text-rich environment. He goes on to say:

> *Without an understanding of what the mind was designed to do in the environment in which we evolved, the unnatural activity called formal education is unlikely to succeed.* (How the Mind Works 342)

Without question, effective practice is the engine that drives long-term learning, but what are the elements of effective practice? The nature of how neural processors work together and how long-term memories are formed provides valuable insights for both designing lessons and coaching learners how to use effective practice strategies.

The activation of multiple processors at the same time, for example, increases the probability that neurons will wire together to form the neural structures and neural pathways necessary to lead from comprehension, to automaticity, and to long-term learning. This rewiring takes time and is an unconscious process that involves both declarative (i.e., memory of events and facts) and procedural memory (i.e., skill memory, especially involving sequences such as the playing of a piano scale).

Research shows that long-term learning generally requires frequent repetition over an extended period of time. Long-term learning doesn't happen overnight when one crams to pass a vocabulary quiz or consciously memorize a dialog for the next day. Short, frequent practice sessions repeated over a longer period of time appears to be the most efficient way to increase language proficiency.

Of course language learning also depends on the quality and comprehensibility of the language input being practiced. Language models need to be at a suitable level of comprehensibility, and this is where placement and on-going testing are essential. If students are not working with language in an optimum range of comprehensibility, their practice is inefficient and in some cases counterproductive.

Once students are placed, a well-designed multimedia lesson can deliver optimum language through a fluid combination of visual, auditory, and contextual inputs. It can present and coordinate these inputs in ways not previously possible. In addition, it can interact with learners and gather data about their level of comprehension and activity.

With careful sequencing and extension of the language models, students can be guided to where they recognize, comprehend, and can respond appropriately to the modelled language patterns and to variations of those patterns without the need for immediate text or translation support. Then, if they practice saying and recording the language models, they can activate yet another processor, the phonological processor, though this processor would also have been used to some degree in the listening phase.

As listening and speaking fluency develop, the student can then focus on text, both reading and writing – the *4 skills path*. It is interesting to note that in comparison with listening and speaking, reading and writing processors are relatively slow. Listening and speaking fluency can support the learning of reading and writing skills, but reading fluency can slow down and interfere with the development of listening skills, in part because the slower but stronger reading processors will dominate and cause the listening processors to swerve off course, interrupting the automatic decoding mechanisms that must be developed.

Following the *4-skills path* provides repetition and multi-modal reinforcement that leads to long-term learning. It can also increase motivation, especially if the content is varied and extended at each step. Taken together, and repeated over a suitable length of time, these multiple inputs facilitate long-term learning, not only of vocabulary, but also of the unconscious decoding mechanisms that break down and tag chunks of language for their grammatical and syntactic properties. Without these mechanisms, few sentences of any length can be understood even if the definitions of each word are known.

Blended Learning

Guided by research, learning theories, and by actual classroom experience, CALL is now moving toward a blended model where the multimedia computer provides the necessary optimal input and practice activities, and the classroom provides the human element where the language models come to life and are extended in a social context.

Viewed from this blended model, both classroom and multimedia activities play an essential role. Without the social environment of the classroom, learning is tedious, unmotivating, and too restrictive to meet the needs of learners. Typically, drop-out rates are reported to be 80 percent or more in e-learning environments where little or no classroom support is available. On the other hand, without the effective practice provided by well-designed, media-rich courseware, language learning is slow, painful and discouraging, a fact borne out by the results of traditional language learning models which suffer from a lack of practice and an overemphasis on memorization and conscious rule learning that is soon forgotten.

In our experience, the blended model can reduce language-learning time significantly, in some cases by 50 percent or more, depending primarily on the following variables:

1. Scheduling of practice sessions for optimum frequency and duration.
2. Quality and design of practice sessions, supported by coaching, feedback, and suitable learning tasks.
3. Sequencing of content and an appropriate mix of skills so that the strategic support elements of language are developed in a well-designed learning path.
4. Classroom sessions that provide *extension and personalization* of the language models, including the assignment of reading and writing exercises.
5. Suitable technical infrastructure and support.

Once a suitable infrastructure is in place, teacher training is generally the most important factor in the success or failure of a CALL initiative. In the blended model, where practice is emphasized more than ever, students need to be coached and monitored. The quality and design of practice sessions must be supported by coaching and feedback, and this is most effective when provided by a teacher who knows the student and has a good idea about what differentiates effective practice from inefficient practice, the kind that wastes valuable time and de-motivates students.

Well-designed programs can assist the teacher, both in providing coaching and in pointing out practice strategies and materials that are useful at various stages of the learning process. A good records management system can also analyze the study data to identify students who are practicing in inefficient ways, such as not recording or using speech recognition exercises often enough, or those who have other problems that need early intervention. This can be a big time saver for overworked teachers who deal with large numbers of students.

In our own courseware and in our Records Manager, we have developed a new metric, the *Completion Percentage,* to assess how well students are utilizing each lesson. The Completion Percentage is a measure of the number of *micro-learning-steps (MLS)* that a student has completed. Taking our cue from the neural sciences, we define a micro-learning-step to be any one of the following: (1) listening to and comprehending a language utterance, (2) recording and monitoring an utterance with comprehension, (3) processing information and completing a task in the target language, and (4) reading or writing a sentence or phrase with comprehension in the target language.

To further assist in the monitoring and coaching of students, we have developed specialized software, the *Intelligent Tutor*, which combs through the details of each student's learning activities and summarizes the results so that teachers can identify which students need additional coaching. In addition, the *Tutor* provides specific suggestions about *how* the class and individual students within the class might improve their practice strategies.

Assessment

Given the problems inherent in implementing large-scale CALL programs, price and accountability are also important factors. A higher-priced product with value can end up being much less expensive, per student, than a lower-priced product with little or no learning value. Quality and effectiveness matter and they can and should be demonstrated. This can be done in a well-designed pilot program or by examining data that supports the claim of a courseware provider.

For CALL courseware developers such as DynEd, the challenge is to continue to create and support lesson designs and activities that can optimize language learning and show quantifiable benefits. Feedback from well-informed teachers, students, test results, and study records from around the world continue to suggest new patterns and provide ample opportunities for further research in this very exciting field.

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On the Cusp: New Developments in Language Teaching

This is an exciting time in the field of language teaching. Yet many ESL/EFL professionals are either unaware of or remain indifferent to developments in other fields that are of fundamental importance to language teaching, such as the evolving role of computer assisted language teaching (CALL) and recent learning theories based on neuroscientific studies. New areas of research outside the profession have barely made a dent in how ESL/EFL teachers and academics approach the classroom and materials development, while language teaching conferences and journals continue to focus on many of the same issues that have preoccupied the profession for many years. This inwardness, I suggest, threatens the integrity and competence of the profession, especially in relation to those countries, such as China, where more efficient English language teaching solutions are being sought.

Evolving Role of CALL

Nowhere is fundamental change more apparent than in the area of computer assisted language learning. This is a major breakthrough because it allows learners to interface with the target language in new ways, especially with listening-based activities that should be at the heart of language learning.

Well-designed multimedia lessons can now *coordinate* visual, auditory and contextual input in ways that a book or language lab cannot. It is now possible for true beginners, for example, to receive and interact with optimal language input from the very first lesson with little or no need for text support. By displaying a simple picture or icon, such as a book, a triangle, or a number, the learner can process the foreign-sounding phrase and immediately know the meaning. No need for text. No need for explanation.

Using CALL, visual and auditory input delivered in a well-ordered sequence can lead the learner to understand the grammar, syntax and vocabulary of the target language with no need for text support. Learners can interact with the presentation, and have their interactions recorded into their study records and even influence the pace and level of the presentation. This is not an insignificant development given the role that text and textbooks have played in traditional approaches to language teaching.

For years people in the profession have said that listening is the key skill, yet most ESL/EFL classes remain dependent on text-based and reading activities as their primary source of language material. Even during listening exercises, many teachers still ask the class questions while those questions are displayed on a screen or in a textbook. A better strategy would be to reveal the text *after* the students have answered each question, or not at all, depending on the situation and student proficiency level.

This dependence on text is unfortunate because research shows that reading and listening skills use different pathways within the brain. In addition, the auditory pathway is considerably faster, involving language processors rooted in the brain's cerebellum, which is far more involved in auditory processing than in any other species. According to one neuroscientist,

> "At the rate words are presented in speech, the speaker or listener must be able rapidly to generate associated words and avoid letting earlier associations interfere. The cognitive search process must be as rapid but as shallow as possible. Any slight tendency to perseverate would entirely derail the process." [Deacon]

Exposing students to auditory input along with text support sets up competing sets of input, making it more difficult to develop the auditory processing speed necessary to decode incoming speech. As another neuroscientist, Richard Restack says, "Competition between sensory channels can also prove disruptive." [Restak]

When students are studying a lesson, they should, therefore, be coached not to rely on text until *after* they have developed their ability to understand and repeat the key sentences. However, many students (and teachers) find the use of text to be a comfortable way to learn because it gives them time for conscious analysis. Though it may be comfortable, research indicates that it isn't effective. Again, with well-designed CALL lessons, dependence on text can be reduced and the effects on learning can be measured with a fair amount of control.

Listening and speaking skills both involve complex sequences of neural processes and need to be developed in a step-by-step sequence, moving from short, simple phrases to longer, more complex sentences. Students who say they *need* to use text as a support have generally been placed too high and should be encouraged to focus on easier material, at a level where they can process the language input without text.

Wiring the Brain for English

Learning involves changes in the brain. Electrochemical changes and new connections between neurons must occur for learning to take place. Some of these changes happen quickly, and some happen over a period of days or weeks. One very important advantage of multimedia study is the fact that many parts of the brain are activated at once. Having students listen, look at a visual display, process the information, and then record it can activate several areas in the brain and facilitates long-term learning. This is far different than looking at wordlists or sentences and then trying to memorize them. As the famous neuroscientist Donald Hebb said as early as 1949:

Neurons that fire together, wire together.

CALL multimedia language exercises can provide this kind of learning activity, again and again, with detailed record-keeping to monitor student activity.

Multimedia is, like the name implies, *multi*-modal. A media-rich lesson gives students practice in using visual and other contextual clues to process the incoming language. The rapid *integration* of visual, contextual, conceptual, and auditory input, all within the constraints of working memory and without the distraction of text is the basis for developing listening and speaking skills.

Memory, Learning and Practice

Neuroscientists refer to two different types of memory: declarative (explicit) and procedural (implicit). Declarative memory is used to remember specific events or facts, and procedural memory involves the learning of a sequence of actions or skill acquisition.

Though much of the mental lexicon of a language depends on declarative memory, which deals with facts and events, the mental grammar of a language depends on procedural memory, a "distinct neural system"[Ullman] which deals with motor and cognitive skills. Procedural memory depends on a network of neural structures, including cerebellar structures, that execute relatively automatic subroutines. Neural research suggests that these subroutines are instrumental in rapidly pre-processing sequences of rule-governed sounds. These are especially important in developing listening comprehension, where processing speed is critical. There is simply no time to reflect on or search for rules to decode what one is listening to. Automaticity is required, and this kind of skill acquisition requires practice and *operational* understanding as opposed to conscious knowledge – which can even interfere by diverting one's attention and losing track of what is being said.

Learning techniques that develop procedural memory and unconscious routines are therefore central to effective language learning. This is especially true for listening and speaking development. Practice is the key and should predominate in any language learning environment. Repetitive, interactive exercises, though seemingly mechanical, play an essential role in this type of learning and can better prepare language students to more confidently participate in classroom-based communicative activities such as oral presentations, role-plays and paired activities where well-practiced language routines can be personalized and extended with relative success and confidence.

Language Learning is Skill Development

One of the failings of traditional language learning practices is the attempt to treat language learning as a body of knowledge to be consciously learned. Though conscious learning certainly plays a part in language learning, studying grammar and memorizing vocabulary is *not* the way to learn language efficiently. This approach fails to address the larger issue of procedural memory and skill acquisition which is at the heart of language learning and which CALL can address.

Learning to communicate in a second language is like learning how to play a musical instrument. Primarily, it involves a set of sensory and cognitive skills interacting with language input and long-term memories that are retrieved and utilized unconsciously in the working memory. As pointed out above, skill development requires effective practice, and this practice must be done on a regular, frequent basis. For language learning, the most effective practice involves multi-modal, coordinated sets of input that progress from listening to speaking, to reading and then to writing: the *4-skills path*. CALL lessons can play an important part in providing this kind of practice, especially the repetitive practice that is at the heart of skills development. Listening to a sentence several times in succession, voice recording and playback, and speech recognition exercises where students practice making questions are all examples of this kind of repetitive practice.

Studies of the brain and long-term memory formation show that repetition strengthens and even builds neural connections and subassemblies that process language. But repetition needn't be defined as parroting the same thing over and over. There are different kinds of repetition. One kind of repetition, "shallow" repetition, is the repeating of an exact phrase or group of phrases. However, since language processing involves the use of a large number of processors to decode the sounds and syntactic elements of language, it is helpful to recognize the fact that though sentences may vary on the surface, their underlying structure may be the same. This allows for a different kind of repetition, "deep" repetition.

Deep repetition involves the repetition of the *conceptual* content rather than the surface details. For example, when focusing on one aspect of the life of a fictitious character, such as their daily schedule, one may repeat the content at a deep level without using any of the same content words by shifting the communicative focus to the lives of each student and *their* daily schedules. This kind of deep repetition involves many of the same conceptual processors and helps to wire in the neural assemblies necessary to process that set of concepts in the target language.

Varying the learning modality is another way to get useful repetition. By following the "*4-Skills Path*" students can practice communicating a set of concepts (information) in different ways. First, content is introduced in a suitable context through multimedia-based listening and speaking activities which are followed up by classroom activities. After going through a lesson several times on different days -- moving from limited comprehension to full comprehension -- students begin to summarize portions of the lesson, ask and answer questions about the lesson and then make oral presentations or do role plays. These activities are then extended through paper-based reading and writing exercises, either by adding details or by personalizing the content, while still respecting the underlying conceptual content. Integrating the 4 skills in this way provides deep repetition without boring students with repetitive tasks that are needlessly tedious.

This 4-skills learning sequence provides repetition that employs many of the same language processors, brings in new vocabulary and grammar, and brings in additional neural processors (orthographic, etc.) that lead to long-term learning. In other words, the linking and sequencing of listening, speaking, reading and writing activities can provide the type of repetition necessary for skill development – but without the sense of mechanical parroting – though a certain amount of shallow repetition is also necessary as well.

Shallow repetition can and should be provided through interactive exercises that employ such interactive technologies as speech recognition, which students return to again and again, despite the fact that the tasks are blatantly repetitive. Using the music metaphor, shallow repetition is like the practicing of musical scales and should be done frequently, as a part of every practice session.

Sequencing Language Models

Perhaps the most difficult area for teachers to develop is the language syllabus itself. What is it that students should be practicing? What is the learning path? Should the focus be on vocabulary and situational phrases that must be memorized and then pieced together somehow when someone needs to communicate? We all know students who think that the key to language learning is to learn as many vocabulary items as possible. Yet we also know that even if one knew every word in the dictionary, one still couldn't understand a single sentence if the underlying rules of syntax and grammar could not be applied unconsciously. We also know that learning vocabulary items is often an exercise in frustration, because so much is forgotten so quickly.

Again, neuroscience has something to teach us that supports the work of previous writers such as Wilkins (1976), who looked at the underlying conceptual and functional structures of language. In particular, brain research shows clearly that there are highly localized parts of the brain that are conceptual in nature. Poke someone in the brain at just the wrong place, and that person will not be able to determine the relative size or shape of something [Restack].

A key factor in the success of a well-designed ESL/EFL course is the selection of *optimal* input so that language kernels are presented and developed in a learning path supported by student experience and knowledge about the world, including knowledge of content areas such as math and science, not just daily life. Whether we are requesting, suggesting, or explaining, language inevitably involves the exchange of information, much of which can be broken down into concepts such as time, manner, frequency, direction, and degrees of certainty. These concepts are generally marked by a relatively small set of words and grammatical constructions. This set of language elements has great power, because it governs how words and phrases are combined and interpreted – and they occur with great frequency.

Rather than focusing on the uniqueness of each utterance, learners need to focus on the *similarities*. This can only happen if the language presentation is designed to show those similarities – especially important at lower proficiency levels. Order prevails through the application of rules and markers. For example, the verb markers *have+V(n)* and *be+V(ing)* always occur in the same order: *have been arriving*. There are no exceptions. In English, one cannot say: *is having arrived*, where the markers are reversed. And we cannot use more than one modal, as in *will can go.* Instead, we say: *will be able to go,* which has the same meaning. Regardless of the verb, these rules still apply and tell us how the verb is being used and interpreted. This ordering or concatenation is done unconsciously by neural assemblies that operate like a chain of little subroutines in a software program.

It isn't that language diversity or richness comes from a large vocabulary. Rather, it comes from the variations and combinations of a smaller set of vocabulary and language routines which are processed and applied automatically and then adjusted and interpreted to meet the situation. Fine adjustments and interpretation are based on other sensory input such as visual information, context, vocabulary, and previous knowledge – and employ symbolic thinking of a kind that is unique to humans. But in terms of processing speed, it is a minor adjustment to something done before, like shooting a basketball, or picking up a telephone. Each action is unique, but is appended to a learned sequence that functions like a template. The action sequence is the same, but the final adjustments, though critical, allow for learning and memory efficiency.

To see the power of combination, it's useful to point out that just five numbers: 1, 2, 3, 4, 5 can be arranged in 120 distinct sequences. With ten numbers, the number of distinct sequences grows to 3,628,800. This illustrates how powerful a small number of language items can be, since the combinations are enormous. However, the application of a single rule to the above set of numbers, such as to require that larger numbers must follow smaller numbers, reduces the number of possible combinations to just 1, a clear example of rule-governed simplicity.

In the search for a Universal grammar that underlies all languages, the evidence mounts that this grammar is largely conceptual, and biological in nature, based on how we perceive and experience the world. Organizing the world into time, space, properties, motion, forces and causality are universal and are how we construct the reality about which we communicate.

In this regard, we must also not forget the essential role that visual input and context play in language. The visual display of an icon such as a triangle activates many areas of the brain. The recognition of a familiar object (or icon) activates knowledge, concepts, and associations about that and similar objects – which are utilized to decode the meaning of a string of sounds. Examples of this 'iconic' approach can be found in *First English* and *English for Success*, multimedia courses which were designed for school-age children and take advantage of what the students already know to help bootstrap the language learning process.

With repetition and appropriately sequenced examples, a multimedia lesson that employs a visual, "iconic approach" can be particularly useful in helping learners comprehend and acquire the underlying grammatical-semantic language structures that are thought to be universal and embodied in the brain.

From this perspective, the grammatical-semantic underpinnings of English are like the trunk and branches of a tree. In contrast, the vocabulary and expressions are like the leaves. There are many leaves on a tree, but without the branches they just drift to the ground.

The trunk and branches are therefore the key elements in a syllabus: the grammar and syntax related to the concepts we need to express. And just like a tree, some branches are offshoots of others and deal with higher levels of detail or abstraction not suitable for the beginner. The key point here is that developing the trunk and branches is far more important than piling on lexical items that have nowhere to go but short-term memory.

Furthermore, from our experience, it seems that the branches, when exercised, become sticky. When specifying size or shape, for example, the brain seems conditioned to look for lexical items that will fit onto that branch. Once there, these items have the tags necessary for quick retrieval. This argues against the traditional use of word lists to be memorized.

Instead, lexical items should be presented so that their grammatical function and conceptual meaning are clearly marked. Once the main branches of the tree are established, elaboration and extension of the language to suit the specific needs of the learner, including the building of a rich vocabulary, becomes increasingly efficient.

Emerging Blended Model

Countries with a growing demand for fluent speakers of English are increasingly impatient and dissatisfied with traditional methods of instruction. This has led to large scale, government-sponsored research initiatives that are redefining the role of language teachers and looking for ways to use technology to increase efficiency and cut costs. With the rapid pace of change, teacher training programs will need to redefine their curricula and bring in new areas of expertise.

As the advantages of multimedia and CALL become clear, language education is moving toward a blended model -- a blend of computer and the classroom. The computer provides the necessary language input and practice activities, and the classroom provides the human element and language extension. This combination allows learners to approach language study much more effectively. With training in how to integrate CALL into their lessons, teachers can finally put into practice many of the theories of language acquisition that have developed over the years and which are now finding support in research from other fields, particularly the neurosciences.

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Recursive Hierarchical Recognition: A Brain-based Theory of Language Learning

The advent of multimedia computers allows for *multimodal* input and practice, where learning activities can take advantage of the hierarchical structure of the human brain and the interplay between listening, speaking, memory, and the pattern-recognition logic that is at the heart of human intelligence.

Listening and speaking-based activities can now be coordinated with visual, conceptual and phonological inputs not possible with textbooks, or even in classroom activities. This creates opportunities for fundamental changes in language learning, including a rethinking of the relationship between the 4 skills, with the skills of listening and speaking elevated to playing their key roles. It also brings into focus the realization that too much precision and language 'knowledge' may work against the learning process. In fact, a tolerance for ambiguity becomes a predictor of language learning success and guessing becomes one of the learning skills to be encouraged in the language learning process.

Recursive Hierarchical Recognition (RHR) is a learning theory that addresses these issues. It has been developed to guide the development of learning materials and activities, and is supported by the study records of thousands of students studying in diverse circumstances in over 50 countries. As more data is collected, it continues to evolve.

This presentation offers an overview and key concepts of RHR, such as Multimodal Input, Hebbian Learning, Temporal Tension, Conceptual Chunking, and Language Bootstrapping.

Procedural Memory and Automaticity

From the neurosciences, we know that there are several kinds of memory systems. Episodic memory is responsible for explicit memory (event and fact learning), that is, learning with awareness. Procedural memory is responsible for implicit memory (skill learning), that is, learning without awareness [Restak: p 79]. Procedural memory is used for carrying out a skill. A skill involves the activation of an automatic sequence of actions that have been acquired through repetition and/or practice over a suitable period of time.

Procedural memory depends on a network of neural structures that execute relatively automatic subroutines. RHR assumes that unconscious neural routines – not knowledge about a language – do the heavy work of breaking down, chunking, and reassembling language for comprehension or oral expression. These neural routines involve pattern recognition, and follow the learning sequence: (1) familiarization (2) recognition (3) comprehension, (4) mastery, and (5) automaticity.

To accelerate language learning, we must facilitate the above sequence. This is accomplished through the multi-modal input of language models that follow a learning path that makes efficient use of Long Term (LT) memory. Language input and language practice work in a recursive, circular manner to wire in the pattern-recognizing subroutines.

Multimodal Input

Also from the neural sciences we are learning about the nature of brain plasticity, the kinds of changes in the brain that occur when learning takes place. We know that multimodal activities in particular enhance the creation of new or strengthened synaptic connections, which is the stuff of new memories, especially procedural memories. As the famous neuroscientist, Donald Hebb said: Neurons that fire together, wire together. This is the basis for Hebbian learning: that repeated excitations of a sequence of neurons modifies the synaptic connections between those neurons.[Hebb: pg 62] As a result, RHR stresses the importance of multimodal practice: listening, seeing, speaking, acting, and processing information.

By multimodal, I mean the coordinated, synchronized activation of visual, auditory, conceptual, and other systems within the brain – something that well-designed multimedia exercises can provide – unlike textbooks, which are page-based, non-temporal, and require initial orthographic processing.

Language processing requires many neural systems to interact, with information flowing upward and downward within the brain. Figure 1 is an oversimplified diagram that shows how various processors in the brain communicate with each other and the working memory.

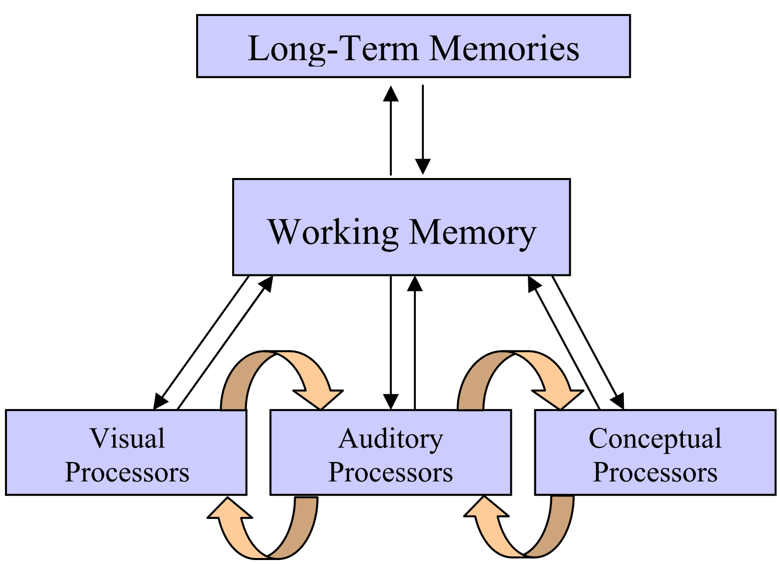


Figure 1

Well-designed multimedia exercises activate and synchronize the appropriate processors in ways not previously possible. These processors work in parallel and interact with the working memory and long-term (LT) memory to piece together and interpret language and sensory input. A well-designed multimedia program optimizes this process, both in the presentation of language models and in the interactive exercises that support them. In particular, long term (LT) memory, visual information, and conceptual processors work together to help decode and fill-in comprehension gaps.

The process begins by presenting visual inputs arranged so that the general meaning can be inferred without any language or auditory input. This takes advantage of the brain's natural ability to make sense of things and fill-in details or patterns to fit one's expectations. In Figure 2, for example, the brain instantly and naturally fills in the expected pattern. In other words, it takes incomplete information and extrapolates, fills in, or infers the rest. RHR takes advantage of this natural 'learning force.'

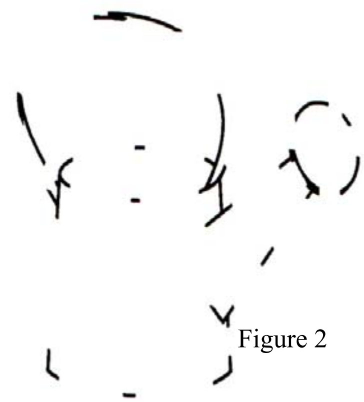


Figure 2

With well-designed multimedia exercises, we can develop the oral skills, step by step, taking advantage of how brain systems work together, how memories are formed, and helping the learner facilitate the learning process by using what is known to fill in gaps and discover rules and patterns that lead to more efficient processing, which is the key to oral fluency, and ultimately to all 4 skills.

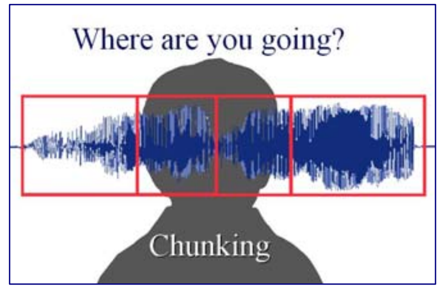
During practice sessions, students are coached to listen multiple times to a language model in context and supported by synchronized, visual input of an iconic nature, such as geometric figures, charts, or arrangements of pictures designed to express causal relationships. These kinds of visuals help learners to infer the meaning of an utterance, or a series of utterances, especially if they are animated or brought into focus so that the visual and auditory inputs are appropriately synchronized. With each passing sentence or question, the underlying language patterns and gaps are perceived, with or without conscious awareness of the patterns themselves. As this process is repeated over several days, the familiar patterns begin to carry meaning even into novel situations.

To accomplish this, the language models must be carefully arranged to help learners to discover the underlying language framework and resolve ambiguities before they lead to frustration. Learners can generally guess the meaning by using their knowledge of the world and the conceptual logic that is wired into our brains. This guessing process, followed by the elimination of wrong choices, appears to be a much faster way to learn than trying to learn every detail and then piece things together.

Some neuroscientists believe this conceptual structuring is done through millions of tiny cortical columns in the brain's neocortex, each one of which processes a specific type of sensory input. When groups of these columns are switched on repeatedly, they wire together to form a networked assembly that can be instantly activated as a whole, thereby increasing the speed with which language input can be processed and chunked. RHR predicts that appropriate multi-modal practice activities accelerate this wiring process.

Chunking and Temporal Tension

When developing the oral skills, RHR follows the "4-skills path" [Knowles 2004]. Listening comes first, supported by visual, conceptual, and LT memory inputs. Oral repetition follows, with the aim of developing the skill to organize language into phrases, or chunks. This is done by having the student focus on parts of each sentence until the parts can be grouped together and repeated as a whole. For example, “The person on the left is a woman” may be broken into three units at first: (1) The person (2) on the left (3) is a woman. Then, with practice, the student can break it into 2 units: (1) The person on the left (2) is a woman. Then, with more practice, the students can repeat is as a whole: “The person on the left is a woman.” Once the student can do this, over a period of several days, the student will be able to process the entire sentence even if spoken quickly.



During the above activity, RHR suppresses any text support, especially for older learners and false beginners. The use of text can interfere with the listening process and reduces the temporal tension that activates the pattern recognition logic of the brain. Temporal tension, provided that it’s the right amount, helps to develop the chunking skill. Another disadvantage of text is that it often causes graphical interference – where the learner’s previous phonetic model of the text distorts what is actually heard.

Once students are able to listen to and repeat the entire sentence – with confidence and relative fluency – they can begin to look at the text for confirmation. This provides another form of repetition, and additional orthographic input, which reinforces the memory. Beyond this, writing exercises can provide yet another opportunity for practice, input and extension.

In our experience many students who consider themselves to be at an intermediate or advanced level are surprised by their inability to process language without text support. Their oral fluency level is much lower. Such students have never developed the automaticity necessary to chunk language. This explains their lack of confidence and limited oral fluency. In RHR, chunking ability is proportional to fluency, and chunking is a skill that can develop through frequent and sequenced practiced.

In RHR, listening and speaking are the primary language skills and should always come first in the skill acquisition process. Though learners and teachers may find the use of text a useful and comfortable support, this comfort comes at a high cost because it eliminates the temporal tension. An appropriate amount of temporal tension leads to attention, efficient practice, and language automaticity. Learners should be encouraged to leave their comfort zone.

RHR predicts that reversing the order of skills – which is the common practice – delays the language acquisition process. As argued above, relying on text support short-circuits the process of developing the gap-filling, pattern recognition circuits necessary for oral skills to develop quickly. Therefore, students who are uncomfortable or unable to practice without text support should be given lower level material to work with, and coached so that they can develop a more efficient way to practice.

The temporal nature of oral communication is fundamental. Oral communication is temporal, not spatial. Unlike text, which is static and visible, speech input flows quickly through the brain. Language processing must be done quickly and the input must be held in memory buffers that are limited in size.

As the cognitive scientist Steven Pinker points out: "Phonological short-term memory lasts between one and five seconds and can hold from four to seven "chunks. (Short-term memory is measured in chunks rather than sounds because each item can be a label that points to a much bigger information structure in long-term memory, such as the content of a phrase or sentence."[Pinker 1997: p 89]

The pressure to hold auditory information in limited memory buffers creates temporal tension, which can engage and motivate the learner – if done in short, frequent sessions. However, too much tension can lead to frustration, so it is essential to place learners into a learning sequence where the length and complexity of the target language is appropriate. Hence a good placement test, monitoring, and frequent testing are important. These only have utility, however, if they can assess the chunking skill of the learner. An assessment of vocabulary, for example, would not be appropriate.

In addition to placement and ongoing assessment, language input should be designed so that the key patterns are in abundance and appropriately sequenced. Without this preparation, RHR cannot work, or will be severely limited. The patterns must be there to be recognized and acquired. Without that, the language input becomes noise to the brain, not music, and tension becomes frustration and defeating.

Conceptual Sequencing

In RHR, language chunks are built around concepts – which express elements of information – or language functions – which signal the type of speech act (e.g. *request*, *suggestion*) being expressed. Examples of concepts include: point of time (*after arriving*, *when it started*), frequency (*several times a week*, *sometimes*), and events (*the car went off the road*, *they practiced*).

Teaching discrete words is avoided. Instead, lexical items are presented in phrases, such as ‘a book’, ‘a red book’, ‘a green book’ ‘open the red book’, etc. Presenting vocabulary in this way – without text support at first – facilitates conceptual chunking while also teaching the vocabulary.

Processing a single word or number is a relatively shallow process. It's fast and can easily be remembered for a short time. However, research suggests that as the level of processing deepens, more neural linkages and associations facilitate long-term learning [Craik 1975]. Abstracting and generalizing are natural processes that are conceptually based and provide a means for storing information and consolidating memories. Routines, templates, and conceptual 'patterns' seem to be the building blocks of thought and language.

Many of the most common words work as indices, or switches, to concepts or sets of concepts. These marker words switch on various concept areas. The preposition 'at' for example signals location in time or space. Such marker words head a phrase that can be chunked around a concept. The brain anticipates that some location in time or space is forthcoming: 'at her house' or 'at the end of the performance.' Similarly, the word 'for' activates a set of conceptual areas, including duration (for a few minutes) and purpose (for her school). Depending on what words actually follow (e.g. few minutes), the alternative concepts (purpose, etc.) are eliminated.

These examples also indicate how the meaning of a word depends on the words and context around it, which is another reason why RHR rejects word lists. When acquiring a new language, the goal is to facilitate the recognition of patterns, not discrete lexical items.

The hierarchical structure of memories and concepts is a key feature in RHR. RHR suggests that the optimum learning sequence moves from basic concepts such as object and event to complex concepts where many concepts are embedded within other concepts, such as "while he was driving home", which expresses duration but which has other concepts embedded within it (process, direction, etc.). Optimum learning sequences should resonate with how memories are associated in the brain and how concepts are organized in our environment.

Iconic Presentation

In RHR, multimedia presentations make extensive use of icons to support language input. Icons are visual objects that alone or in combination with other icons communicate information independent of language input. RHR uses icons to provide visual cues that work to activate LT memories and associations. This process stimulates the brain to guess meaning which can then be used to fill-in language gaps and identify language patterns.

Examples of icons include: numbers, geometric shapes, symbols, pictures of objects or actions, and charts. For an icon to work, it must connect to the long-term memory of the learner so that it activates a set of concepts in memory. Shown a triangle, for example, the brain immediately activates a set of attributes associated with a triangle. If we now say “A triangle has 3 x,” then one anticipates that x means either side or angle. This is because the attributes of a triangle are inherited in the target language. If the next visual input shows one or more sides highlighted, then the meaning ‘angle’ is eliminated in favor of side. There is no need of translation, provided that the icon is age-appropriate. Obviously if a learner doesn’t know what a triangle is, then it isn’t appropriate as an icon.

Multimedia computers facilitate the use of icons. Animation and the sequential presentation of iconic visuals cannot be done in a textbook, but is easily done in brain-based programs like those developed at DynEd [www.dyned.com] where we specialize in this type of design. The essence of an iconic presentation is simplicity and clarity – to work as an effective mental trigger or mnemonic device. In contrast, the presentation of too much information becomes no information at all.

LT Memory and Language Bootstrapping

RHR makes extensive use of Long-Term Memory. Experience and real-world knowledge is systematically used to aid the acquisition process. Steven Pinker used the term 'bootstrapping' when he hypothesized how children use meaning to acquire language syntax [Pinker 1994]. Unlike an L1 learner, an L2 learner has an extensive LT memory of academic and professional subject matter that can be drawn on to facilitate inductive learning. As a result, learning can be more efficient and motivating, because the brain is solving problems rather than memorizing or communicating about generic content of no consequence to the learner.

An interesting example of how this has been applied is a course for airline pilots: Aviation English [Knowles, 2007]. In situations where an airplane is about to land and the wind suddenly shifts, we can predict and use the knowledge and experience of pilots to anticipate what course of action to consider. This knowledge and experience is language independent. Therefore, a Chinese pilot learning to speak English will use this knowledge and experience to fill in the language gaps and 'bootstrap' the learning process. However, this can only happen if the language input is designed with this in mind, and with the requisite aviation knowledge that the pilot has.

In other words, a student can use knowledge of math and science to learn English; because this knowledge is language independent. If I show you two parallel lines and say "These two lines never X", you know that X means intersect or cross. An example of this approach is seen in the DynEd course, English for Success [Knowles 2004]. This course uses the knowledge of school subjects such as math, science and geography to help 'bootstrap' English language acquisition, in particular academic English.

RHR Blended Model

In relation to the classroom, RHR supports the notion that the most efficient language learning approach is a blend, with well-designed multimedia programs and coordinated classroom activities working together. There is no evidence to suggest that computers can or should replace the classroom.

In the RHR blended model, both computers and the classroom have roles to play. The strengths and the limitations of each are recognized. Language models are introduced and practiced through multimedia-based listening and speaking activities. This is followed up, personalized and extended through classroom activities, and then extended again through paper-based reading and writing exercises in an expanding spiral. Learners are active, not passive, and work at an optimal language level which is adjusted and monitored by the software.

Compared to a classroom-only approach, the advantages of this kind of practice are manifold, particularly in the total amount of productive time on task. If coached properly, the number of learning encounters per session is significantly higher than in a classroom-only scenario and can be monitored.

In addition to computer-based lessons, the classroom provides the human element, accommodating the needs and lives of learners in a social context. Through communication activities such as oral presentations, pair work, role plays, and discussions, learners extend and personalize the language previously presented and practiced in their multimedia sessions. And in the best case, the teacher guides and facilitates these activities, with very little lecturing.

In this skills-based approach, multimedia practice activities form the core of the learning process and provide the conceptual framework for communication activities. The teacher is in overall control, not only in the classroom, but in setting and monitoring the learning paths for the students, who now rely on practice and acquired skills rather than memorization.

Conclusion

RHR makes predictions that can be tested – under the right conditions and with an awareness of the large number of variables that affect language acquisition, including the teacher and testing instruments, both of which have built-in biases. Some of these predictions are:

1. Delaying text and following the "4-Skills Path" accelerates fluency development.
2. Frequent speaking practice which focuses on chunks of increasing length and conceptual complexity without text support results in accelerated fluency.
3. Vocabulary is best taught in phrases rather than in isolation. Word lists should be avoided.
4. Oral fluency facilities reading and writing skills.

RHR offers a new and practical approach to language acquisition and materials design. Brain-based CALL (BB-CALL) materials used in a blend with classroom activities take advantage of this approach, and are now being used by several million students around the world. The traditional, text-based approach needs to be challenged.

Whatever approach one takes, testing, monitoring and accountability should be expected and systematically utilized. Now that computers are available and connected, opportunities for rethinking language teaching principles abound, with plenty of data available to test assumptions. And the insights from neuroscience should be a part of every language teacher's training.

"Human children appear preadapted to guess the rules of syntax correctly, precisely because languages evolve so as to embody in their syntax the most frequently guessed patterns. The brain has co-evolved with respect to language, but languages have done most of the adapting." [Deacon 1997: p122]

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Author's bio:

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DynEd International, Inc. (www.dyned.com)

Mr Knowles has pioneered the development and use of CALL for more than 20 years. His innovative learning theory, RHR, is based on neuroscience, and his award-winning programs are used by students in over 50 countries.

Executive Summary

DynEd was founded in 1987 by the former director of the Language Institute of Japan (LIOJ), Lance Knowles, and a team of engineers. DynEd created the world's first interactive multimedia language learning CD-ROM in 1988 and received a U.S. patent for this invention in 1991.

The learning theory behind the design of its core courses, ***Recursive Hierarchical Recognition (RHR)*** [Knowles], is based on the latest research in the neurosciences and provides a clear alternative to traditional approaches that have failed so many learners.

DynEd has also developed an award-winning administrative software system that monitors and assesses student progress in great detail. DynEd's *Intelligent Tutor* provides study-path management and quality scoring for all students, and serves to improve the implementation of DynEd programs in a wide range of circumstances.

In recognition of its quality, DynEd products have received numerous awards and been approved by Ministries of Education in several countries, including China, France, Korea, Malaysia, Mongolia, and Turkey. DynEd's BEAS course series is the only ELT program that has received ASTD Certification.

However, the most important testament to DynEd's quality has been the test of time, during which DynEd has benefited from many long-term users who have provided valuable feedback that has guided subsequent development.

Pedagogical Framework for DynEd

Fundamentally, DynEd courses are based on research-based approaches to language learning and curriculum design, extensive classroom experience, and advanced human interface design. Evidence for the effectiveness of its courses is based on over twenty-five years of experience in programs from around the world and on recent findings in the neurosciences. In addition, DynEd has access to and actively utilizes the real-time study records of thousands of students from around the world.

What makes DynEd different is its unique approach to the design and use of technology in a blend with teacher-led classroom activities. However, wide variability in the implementation of this blended approach -- particularly its dependence on different teachers using it in very different circumstances -- makes definitive studies difficult. Small sample sizes and questionable test results mean that many formal studies are either misleading or unsubstantiated [Ioannidis]. As a result, a more action-research approach has been taken, with feedback from clients incorporated into courseware updates, Teacher Manuals, Mastery Tests, the *Records Manager*, and the *Intelligent Tutor*. Teacher-training seminars and focus groups have been another valuable source of constructive feedback.

As with most educational products, differences in implementation matter.

DynEd

Theoretical Basis

Some of the publications that have influenced or support the design of DynEd's core products are:

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