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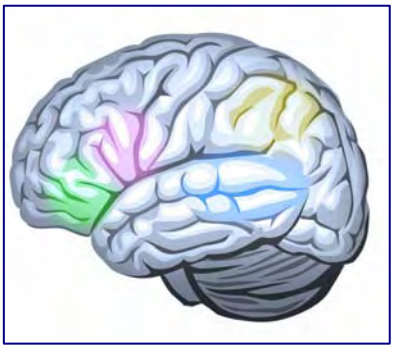
A Brain-based Theory of Language Acquisition: RHR

Research in neuroscience underscores the importance of neuroplasticity, iconic representation, repetition, and the role of media-rich input in skill acquisition. It suggests how different pathways in the brain work together, and how sequenced, *coordinated* inputs facilitate long-term learning.

This paper offers an overview of a brain-based learning theory, Recursive Hierarchical Recognition (RHR). It is an evolving theory based on teaching experience, neuroscience research, and access to the study records of thousands of students studying in diverse circumstances around the world. Some of the theory overlaps with previous language learning approaches, but there is no space here to go into comparisons.



At the outset, RHR assumes that language acquisition is first and foremost a skill-acquisition process. Drawing on neuroscience research, it defines what this means and suggests ways to design activities to facilitate the neural processing that is involved in language acquisition. It also presents a means for sequencing, monitoring and measuring the effectiveness of language practice activities. This paper summarizes a few of the key concepts that are at the root of the theory.

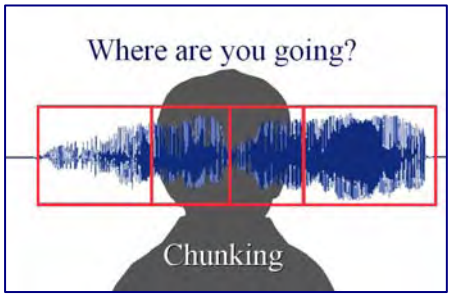
The Traditional Approach

In most countries around the world, students study English in a similar way. In class, the teacher presents and explains vocabulary and grammar. There are textbooks, and there is a heavy use of text even to teach listening. Teachers write words and questions on the board or show the words with flash cards. And students sit and listen and do very little communicating in English. They listen, repeat, and try to memorize, but with few repetitions. Or they look at text, read, and try to memorize words and sentences. In general, what they don’t get enough of is actual language practice, especially listening and speaking. As a result, most students don’t develop their *oral* skills, which are the foundation for reading and writing.

This traditional approach to language learning is knowledge-based. The teacher is the giver of knowledge about English, rather than a coach who helps students to practice the language.

The Demands of Fluency

What is missing in the traditional approach is the kind of practice necessary to develop automaticity, in particular the skill to *automatically* process and *chunk* language, where chunking means to recognize and process *groups* of words rather than discrete items. RHR recognizes that the size and semantic complexity of the chunks that can be processed is proportional to fluency. Memory required to store and process spoken language is limited to a small number of chunks; so if chunks are too small, spoken language input cannot be processed quickly enough.



RHR develops chunking skill. At the word level, groups of words are built around concepts, which express elements of information, and language functions, which signal the type of speech act (e.g. request, suggestion). Examples of concepts include: point of time (when he arrived), frequency (several times a week), and events (the car went off the road).

In RHR, 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 facilitates conceptual chunking while also teaching the vocabulary.

So, a major challenge for the language learner is to develop the *skill* of chunking.

From neuroscience, skill acquisition means to develop procedural memory, which is distinct from the brain’s ‘event’ or ‘declarative’ memory.[Ulman] Procedural memories, which are unconscious, are primarily developed through frequent and repeated practice. Appropriate sequencing is also important, and in RHR chunking practice begins with simple, short concepts and builds to longer, more complex concepts.

To accomplish this, language models must be carefully sequenced to help learners to acquire the underlying language framework and resolve ambiguities that may lead to frustration. This process of familiarization, recognition, and comprehension is facilitated by the conceptual logic that is wired into our brains in the form of tiny, specialized ‘cortical columns’ which are hypothesized to structure all modalities of sensory input. [Hawkins]

The structuring of sensory input is in some sense the grammar of pattern recognition. As various levels and combinations of the hierarchy are activated, connections are made, which create subassemblies, which is the basis for chunking. This

happens over a period of time and is facilitated by frequent encounters with the target patterns.

When processing language, acquired patterns within the input are recognized and automatically chunked using rules of syntax (wired patterns) that are automatically activated by key markers which may be words, grammatical constructions, or groups of words. Only when this chunking and assembling has occurred can conscious awareness of the meaning (comprehension) take place.

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 connected in both the brain and in the world in which we live. This facilitates bootstrapping, which we will touch on later.

In RHR, language should be taught in multi-modal contexts, where visual (not textual) and other situational inputs reinforce conceptual content of language. The modalities of the brain work together, not in isolation. In this light, teaching grammatical constructs is inappropriate. For example, to the brain, the word ‘at’ activates the concept ‘location’ rather than ‘preposition’. 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 several conceptual areas, including duration (for a few minutes) and purpose (for her school).

These examples also indicate how the meaning of a word depends on the words and context around it, 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: music, not noise.

RHR uses the brain’s natural inclination to seek out, recognize, and fill in patterns. This characteristic is seen to be the primary learning force within the brain. If an input is new and unfamiliar, the brain searches for patterns that will allow recognition and subsequent chunking. If a pattern is incomplete, the brain fills it in. The brain enjoys this unconscious process and is motivated to ‘solve’ pattern recognition problems. During the process of acquiring oral skills in a new language, the brain learns to recognize patterns and creatively combine them according to what ‘makes sense’ in the context of the spatio-temporal world which we all share and which is reflected in the organization of our brains.

Oral and Written Skills: The Fundamental Difference

RHR recognizes that the oral skills are temporal skills, where processing speed is crucial. Reading and writing, in stark contrast, are spatial, page-based skills, where processing speed isn’t urgent. When reading or writing, there is time for conscious analysis and memory retrieval. In a text, word boundaries are clear. In speech, word boundaries and phonemes may be blurred or missing entirely. An audio signal needs to be recognized using pattern recognition logic.

In general, listening and speaking employ a set of skills that are applied unconsciously, through hierarchical systems in the brain that distribute and execute tasks, not one after another but in parallel before being recombined with other sensory and memory processes, all of which are necessary for comprehension to occur. The

unconscious processes involved in listening and speaking employ previously acquired rules and patterns which chunk the language into ever increasing size, with very little interaction with conscious thought or analysis, which takes too much time.

When processing speech, language must be chunked so that it can be held in memory long enough to process the meaning. The need to hold these chunks within the limits of short-term memory puts pressure on the brain’s pattern recognition system to organize the input into the largest possible chunks. RHR hypothesizes that the brain is designed to do this, provided that the conditions are right.

In this regard, placement is crucial. Too much pressure causes frustration, and the learner is discouraged. The language input must also 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 use of text in the learning process should be discouraged. If text is available, the learner’s attention is diverted to the text, which is spatial and where there is time for analysis. This diversion removes the pressure to identify patterns so that chunking can occur. In this way, the use of text can interfere with the development of oral fluency. Therefore, RHR follows the 4-skills path: listening, speaking, reading and writing. [Knowles]

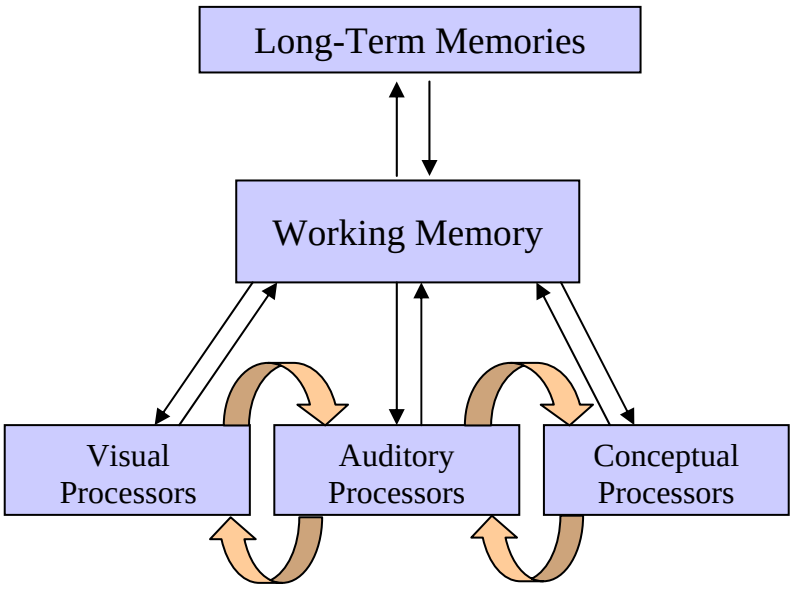
In RHR, the same chunking skill that aids listening works in reverse to aid speaking. Though listening comes first in the learning sequence, listening and speaking develop together, reinforcing each other. This automatic facility for recognizing and processing patterns is what differentiates the oral skills from the written skills.

As the ability to process larger chunks improves, reading and writing skills also improve, because the brain processes the language in larger chunks, whether the source or product is speech or text. In other words, the brain processes ideas or concepts rather than discrete linguistic items.

Within a context, ideas and concepts have reality and ʻmomentum’, allowing anticipation of what comes next. ‘To be or not …..” A computer cannot do this, but the human brain can anticipate that the missing piece is ‘to be’ with incredible speed.

Multi-Modal Learning

The advent of multimedia computers allows for brain-based *multimodal* learning, where learning activities can take full 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. By multimodal, I mean the coordinated, synchronized activation of visual, auditory, conceptual, phonological and other systems

within the brain – something that well-designed multimedia exercises can provide – unlike textbooks, which are page-based, non-temporal, and orthographic.

With brain-based CALL, the learner is active. The learner is free to switch from one activity to another, responding to mental cues such as boredom. Text-heavy linear presentations are replaced by sequenced, multi-modal practice activities. Ambiguity and guessing engage the learner. In fact, too much focus on precision and ‘knowledge’ about the language may work against the learning process. A tolerance for ambiguity becomes a predictor of language learning success and such tolerance then becomes one of the learning skills to be encouraged in the language acquisition process.

RHR elevates the importance of practice. From neuroscience we know that the brain is plastic, not fixed. Frequent practice and experiences shape and reprogram the brain. A musician who practices the piano develops additional neural connections that allow for greater finger control. This can be seen in brain scans. Similarly, students with learning disorders can be helped by repetitive exercises that can help compensate for or even repair disorders by developing new synaptic connections. As the famous neuroscientist, Donald Hebb said: “Neurons that fire together, wire together.”[Hebb] Therefore, the design and use of exercises that target subassemblies of neural connections from several modalities can facilitate skill acquisition, but such acquisition requires practice over a period of time and cannot be crammed into a few intensive sessions.

Language acquisition is essentially multi-modal. Speech is not divorced from context, visual input, and even sensory-motor patterns. Language input and practice should utilize as many modalities as possible. Seeing, speaking, listening, organizing,

choosing, guessing – this is where a textbook is quite limited, and where multimodal, brain-based CALL has tremendous advantages.

Iconic versus Text Processing

RHR makes extensive use of ‘icons’ to present and support language input. Icons are visual objects that alone or in combination with other icons communicate information independent of language input. An icon may or may not be a picture, but it is generally *not* text. This is important, because visual processing is faster and more immediate than orthographic processing, which uses different neural pathways.

An example of an icon is a triangle or the number 2. 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 favour 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 icons cannot be done in a textbook, but is easily done in brain-based CALL programs such as First English [Knowles] and English For Success [Knowles], which are programs designed and used by millions of students as real-world examples of RHR.

Long Term 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. Unlike an L1 learner, an L2 learner can use LT memory to help fill in meaning gaps and facilitate inductive learning, which is motivating and engaging. Research shows that the brain gets pleasure out of this type of activity, provided that the level of input is optimized. Learning is more efficient and motivating because the brain is solving problems rather than memorizing.

An interesting example of how this has been applied is a course for airline pilots: Aviation English [Knowles]. 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."

The Advantages of Blended Learning with Brain-based CALL

RHR is not a theory that supports the idea of self-study. In our brain-based CALL programs, teachers and classroom activities play a key role. The most successful programs are a blend of individualized multimedia practice with classroom activities where the

practiced language models are extended and personalized. Individual practice sessions provide optimal input and intensive engagement with the language models. However, this content is incomplete, like a skeleton. It provides the necessary framework to support language acquisition, but it lacks the personal, individualized character that can come from classroom interactions and presentations.

The classroom is where the language comes to life and is where the student develops confidence, provided that the teacher facilitates communication rather than acts as a knowledge-giver. Though some say that talking by itself is a good thing, in a brain-based approach, the classroom activities should be *based* on the language framework that the student has already practiced, not just random, disjointed, and unsequenced talk.

The teacher no longer has to ‘teach’ the material. Instead, the teacher sets up activities where students ‘perform’ and actively communicate, leaving room for spontaneity and happy accidents to occur, but always with a solid language base to stand on and refer to, review and personalize whenever possible. These activities motivate students because they are relevant and truly interactive, and because students know they are acquiring the new language.

This ‘coaching’ role is where teacher-training and lesson planning become key factors in the success of RHR-based programs. To address this issue, we have provided lesson templates and example activities to help teachers adjust to the new paradigm.

Conclusion

In this paper we have made 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. In any case, some of these include:

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) lessons 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 and rethought. 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 one’s assumptions. And the insights from neuroscience should be a part of every language teacher’s training.

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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.

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