THE SCIENTIFIC FOUNDATION OF EAROBICS®
Proven Techniques for Developing Phonological Awareness and Auditory Processing Skills are Built into Earobics Software

“Research has repeatedly demonstrated the important role of phonemic awareness in learning to read and spell. Earobics effectively incorporates many of the activities that have been used in research to stimulate phonemic awareness.”

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Cognitive Concepts is dedicated to reflecting in its products the latest research findings on the processes and skills essential to reading. As you will see in this publication, all of our product and service development efforts are based directly on techniques that are scientifically based and clinically proven to work.

This publication provides detailed explanations for the specific scientific basis upon which our product line has been developed. It also addresses topics such as the meaning and importance of phonological awareness, the development of phonological processing skills and other important issues.

We encourage education professionals to read this detailed review of our products' foundations, so that they may better understand how to best apply the valuable skill development capabilities of the Earobics product line in their classrooms and fully understand the scientific basis of our innovative approach.
More than two decades of research have proven that phonological awareness is essential to learning how to read. In fact, recent research has shown that phonological awareness is one of the most potent predictors of reading success.

Certain listening or “auditory processing” skills — particularly speech perception and discrimination — are also essential because they are prerequisites for phonological awareness.

The Earobics line of software was designed by a team of literacy and language specialists. The software incorporates decades of research and clinically-proven techniques, resulting in a highly effective and engaging method for systematically developing the key skills that drive the ability to read and spell.

Throughout all Earobics games, learning variables are systematically manipulated to challenge and exercise each skill. The games are also designed to actively engage the student and provide beneficial skill practice.

What exactly are phonological and phonemic awareness?

Phonological awareness is the ability to notice, think about or manipulate the sounds in language (Torgesen, 1997). Phonological awareness refers generally to the awareness of words, syllables, or phonemes (i.e., individual speech sounds), whereas “phonemic awareness” refers only to the awareness of individual sounds in words (such as the three phonemes c-a-t in “cat”). Phonological awareness includes the ability to consciously manipulate the sounds of speech in tasks such as blending, segmenting and rhyming.

If students cannot accurately recognize and manipulate speech sounds, they cannot adequately relate the sounds of language to printed words, a skill essential to decoding words. If children cannot decode words quickly enough, they will not read fast enough to fully comprehend what they are reading.

Phonological awareness includes the following skills:
- phoneme identification
- segmentation
- blending or synthesis
- rhyming
- manipulation

How does phonological awareness differ from phonics?

Phonological awareness involves the auditory and oral manipulation of sounds. It does not involve printed letters. Phonics, on the other hand, is a system of teaching reading that builds primarily on “the teaching of correspondences between printed letters or groups of letters and their pronunciations” (Adams, 1990, p. 50). Both are important to developing early literacy skills.

What evidence do we have that phonological awareness is so important?

Phonological awareness, and specifically phonemic awareness, is one of the most potent predictors of success in learning to read. Phonological awareness is more highly related to early reading than tests of general intelligence, reading readiness and listening comprehension.
Phonological awareness is a reliable predictor of reading achievement and enables early identification of students at risk for difficulty in learning to read.


The lack of phonemic awareness, because of its importance in learning the English alphabetic system, is the most powerful determinant of the likelihood of failure to learn to read.


Phonological awareness is necessary and critical for reading acquisition. It lays the foundations for students’ expectations about the sound structure in words, including the sequence of letters and phonemes and the discrete word-specific characteristics that distinguish one word from another.


Before phonics can be successfully taught, phonemic awareness must be established. Children must be able to hear and manipulate oral sound patterns before they can relate them to print.


II. HOW PHONOTOLOGICAL AWARENESS RESEARCH IS APPLIED IN EAROBICS

A. PHONEME IDENTIFICATION

1. Research Summary
A student who does not recognize and process word sounds accurately will not be able to make the correct associations between letters and phonemes.


Because phonemes are the units of sound that are represented by the letters of the alphabet, an awareness of phonemes is key to understanding the logic of the alphabetic principle.


2. Systematic Development of Phoneme Identification Skills in Earobics

a. Overview
Earobics teaches phoneme identification following a systematic hierarchy based upon the principles of speech acoustics and speech perception. Earobics teaches students to recognize and identify phonemes when presented in isolation or when embedded in words and to recognize the position of sounds in words. The phonemes are carefully ordered based on their acoustic and phonetic properties with the most distinct, or acoustically and phonetically salient, sounds presented first and progressing systematically to sounds that are more difficult to hear.

b. Phoneme Recognition Research Application in Earobics
1) Application in Earobics Step 1: The CC Coal Car Game

The CC Coal Car Game, with 74 levels of play, is designed to teach phoneme recognition and identification and identification of sound position in a word. Additional skill training includes sound-symbol correspondence, discrimination, segmentation, spoken language processing, auditory attention, and memory.

The game starts by teaching the student to identify long vowel sounds because these sounds are easiest to hear. The CC Coal Car pulls into the station instructing the student to listen for a target sound (e.g., "Long vowel 'a' says 'a'. Click on the letter 'a' when you hear the 'a' sound."). If the student does not hear the target sound, the student receives a symbol signifying that the student heard a different sound. If the student is correct, the car fills with coal, and the student receives an engine in the score box. If the student is incorrect, the train fills with dust, and train tracks appear in the score box.

After the student masters phoneme identification when the sound is presented in isolation, the phoneme is presented within the context of a word. At this level of training, the student identifies whether the target phoneme is in the word. For example, the student is instructed to listen for the long vowel 'e' sound. The student hears a word (e.g., "bike" or "bee") and identifies whether or not the word contains the target sound. The training...
progresses through various levels, teaching students to identify long vowels, short vowels and consonant sounds.

Once the student can identify phonemes in words, (s)he learns to identify the position of a phoneme in a word. This time the CC Coal Car pulls into the station with three cars — an engine, a coal car and a caboose. The student is instructed to click on the engine if the target sound is at the beginning of the word, click on the coal car if the sound is in the middle of the word, or click on the caboose if the sound is at the end of the word. The student listens to words containing consonant sounds, ordered based on their acoustic and phonetic saliency.

2) Application in Earobics Step 2: The Duck Luck and Hippo Hoops Games

In addition to other skills, various levels within Duck Luck and Hippo Hoops address phoneme identification skills. Refer to the corresponding page numbers for full-descriptions of each game and additional tasks that they target.

Duck Luck (page 11)
Hippo Hoops (page 13)
b. Blending Research Application in Earobics Step 1 and Step 2

1) APPLICATION IN EAROBICS

STEP 1: The Caterpillar Connection Game

Caterpillar Connection, with 56 levels of play, is designed to teach word, syllable and phoneme blending skills, auditory attention and auditory memory. Additional skill training includes discrimination of consonants and vowels as well as training in spoken language processing. Learning variables, including the time between stimuli and the perceptual similarity of response choices, are controlled across all levels of play.

The training begins by teaching the student to blend words into compound words. The student hears two words such as “dog...house.” The student clicks on the picture of the correct response from a choice of three pictures. If the student is correct, Katy Caterpillar turns into a butterfly, and the student receives a rewarding caterpillar in the score box. If the student is incorrect, (s)he is gently corrected, and a stick appears in the score box.

Once the student masters blending words into compound words, (s)he blends two syllables into words (e.g., “but-ter”) and then two phonemes into words (e.g., “m-e”). Once the student masters blending 2 syllables and phonemes, the student is asked to blend 3 syllables, then 3 phonemes and finally 4 phonemes into words.

As the training progresses, the student builds auditory memory as the time interval between the segments gradually increases from .25 to 2.0 seconds, requiring the student to hold the sounds in auditory memory for longer periods of time. Auditory memory is critical for blending and ultimately for decoding.

Additionally, after the student is able to blend the segments at the various time intervals, the perceptual similarity of the response choices becomes more challenging. Initially, the three response choices are not perceptually similar. As the training progresses, the response choices become increasingly similar (e.g., “nose, rose, hose”), requiring the student to make finer-tuned discriminations among the response choices.

2) Application in Earobics Step 2: The Pesky Parrots Game

Pesky Parrots, with 60 levels of play, systematically teaches syllable and phoneme blending skills as well as auditory memory, auditory attention, phoneme discrimination and word closure. Additional skill training includes: auditory temporal processing, auditory sequential memory, and spoken language processing. Learning variables, including the time intervals between sounds and the perceptual similarity of the response choices, are controlled across all levels of play.

The training begins by teaching the student to blend from two to four syllables into words. The student listens to the parrots speaking syllables (e.g., “ba-by”) and clicks on the picture of the correct word from a field of three (e.g., “baby, robot, chicken”). If the student is correct, a parrot flies by and drops a jewel for Pirate Patch. If the student is incorrect, the parrots blend the word for the student showing him/her the correct answer and drop a coconut instead of a jewel.

As in the Caterpillar Connection game, Pesky Parrots also builds auditory memory as the time between the syllables is systematically increased from .25 seconds to 2.0 seconds. This builds auditory memory, as the student is required to hold the sounds in auditory memory for increasingly longer periods of time.

Once the student can blend syllables at the various time intervals, the response choices become more challenging. At first, none of the choices are perceptually similar. As the training progresses, two and then all three of the choices become more similar, requiring the student to make finer tuned discriminations between sounds (e.g., “snowman, snowball, snowflake” or “racket, rocket, rabbit”).

The training progresses to teaching the student to blend two up through four phonemes into words starting with simple and moving into complex syllable structure. For example, the student will hear “s-k-i-n” and click on the picture of “skin” during Task 8 (blending four sounds into a word with complex syllable structure). The program advances very systematically through increased word length and complexity of syllable structure (e.g., blending two sounds into a word with simple syllable structure progressing through blending four sounds into a word with complex syllable structure).

Once the student masters blending four phonemes into words, the program advances to teaching word closure. This task requires the student to fill in the missing sound segment when a part of the word is omitted. At this level, the student blends from two to four syllables or phonemes into words when one of the segments (final, initial or medial) is missing. For example, the student hears “d-o-_” and fills in the missing sound to create the word “dog.” The student then selects the picture of the dog given a choice of three (e.g., fin, dog, cake). In addition to building word closure skills, this task also requires the student to blend sound segments and build auditory memory. As in
the previous levels of play, the perceptual similarity of the response choices is carefully controlled.

C. SEGMENTATION

1. Research Summary
Phonemic segmentation (i.e., the ability to break a word into its individual sounds) is a prerequisite for linking sounds to corresponding letters and subsequent word identification. Phonemic segmentation training strengthens the ability to identify words and their constituent parts.


2. Systematic Development of Segmentation Skills in Earobics

a. Overview

Earobics teaches critical segmenting skills following a developmentally appropriate hierarchy. Training begins with counting non-speech sounds and speech sounds and progresses to segmenting words into syllables and words into phonemes. Important learning variables, including the time interval between sounds and the amount of auditory feedback, are systematically controlled across the various levels.

b. Segmentation Research Application in Earobics
1) Application in Earobics Step 1: The Rap-A-Tap-Tap Game

Rap-A-Tap-Tap, with 16 levels of play, is designed to teach auditory temporal processing, auditory short-term memory and syllable and phoneme segmentation skills. Other skill training includes auditory attention and spoken language processing.

The training begins by teaching the student to count drum beats. Initially, the student is asked to click on the mouse once for each beat (s)he hears in a series of one to four drumbeats. If the student responds correctly, the band plays music, and a musical note appears in the box. If the response was incorrect, an empty musical staff appears in the box. The training teaches the student to process sounds more quickly by providing practice at time intervals varying from 1.0 to .25 seconds. Auditory feedback is initially provided for the student, allowing the student to hear the beats on the drum as (s)he clicks on the mouse. As the student progresses, the auditory feedback is removed, requiring the student to recall and count the drum beats independently.

After the student masters counting training with drum beats (s)he learns to count speech sounds. The student hears between one and four speech sounds and is asked to click on the mouse once for every sound (s)he hears. For example, if the student hears “s,” “b,” “d,” (s)he clicks on the mouse three times, once for each sound. The program automatically controls the timing between the sounds and the auditory feedback as in the previous stimulus set.

Once the student can successfully count speech sounds, (s)he learns to break words into syllables. The student is asked to click on the mouse once for each syllable in a one- to four-syllable word. For example, the student hears a word such as “basketball” and clicks on the mouse three times, indicating three syllables (i.e. bas-ket-ball). Initially the student is provided with auditory feedback.
(The student will hear each syllable when (s)he clicks on the mouse.) Once the student can segment one-to-four syllable words while hearing the syllables, the feedback is removed, and the student completes the tasks without auditory feedback.

After the student successfully segments syllables in words, (s)he learns to segment words with two to four phonemes. For example, the student hears a word such as “dog” and clicks three times representing the three phonemes (i.e. d-o-g). The game progresses as above, controlling the number of phonemes as well as the auditory feedback.

2) Application in Earobics

Step 2: The Paint by Penguin Game

Paint by Penguin, with 68 levels of play, is designed to teach a variety of phonological awareness skills, including phoneme segmentation, auditory temporal processing, auditory pattern recognition, auditory sequential memory, phoneme sequencing, auditory short term memory and phonological manipulation. Additional skill training includes: auditory attention, auditory and phoneme discrimination, and spoken language processing. Paint by Penguin incorporates the technique of using a visual representation to help the student represent sound. The game also carefully controls learning variables, such as the time interval between sounds and auditory feedback.

Paint by Penguin begins by teaching the student to identify the number of speech sounds in a series of one to three sounds auditorily presented. For example, the student hears sounds such as “b,” “f,” “s.” (s)he clicks on the mouse three times, once for each sound heard. In response to the student’s click of the mouse, a colored sponge print appears and the sound is repeated. These colored sponges give a visual representation of sound, allowing the student to visually mark and track each sound. A different color is used for each different sound. The use of auditory feedback (i.e., allowing the student to hear the sounds as (s)he clicks on the mouse) helps the student complete the task. As the game progresses, the auditory feedback is removed and the student completes the task without auditory feedback.

In addition to systematically controlling what the student sees and hears, the time interval between the sounds is also carefully controlled. Students learn to process sounds more quickly by engaging in extensive practice at time intervals ranging from 1.0 seconds to .25 seconds. If the student responds correctly, Monsieur Pierre Penguin praises the student, and (s)he earns a splash of paint on the canvas. If the student responds incorrectly, the penguin demonstrates the correct answer, and no splash of paint appears on the canvas.

Once the student masters phoneme counting, the game progresses to segmenting speech sounds in a two- to five-phoneme word. For example, the student hears the word “dog.” The student clicks on one color of paint for each sound in the word (i.e., d-o-g). The words increase in difficulty, progressing from shorter to longer words and simple to complex syllable structure (including two- and three-consonant blends). Auditory feedback is first used and later faded throughout all levels of play as described above.

Paint by Penguin progresses in difficulty from segmentation skill training to sequencing and manipulating sounds (including re-arranging, deleting, substituting, and adding phonemes to make new words). A description of the phoneme manipulation portions of Paint by Penguin can be found in the Phoneme Manipulation section that follows.
1. Research Summary
A student’s ability to identify and produce rhyming words has been found to be a prerequisite for developing more complex phonological awareness skills (e.g., phoneme segmentation and manipulation). It is one of the primary skills to emerge in phonological awareness.

Research has proven that rhyming skills lay the foundation for children’s understanding of the internal sound structure in words.

2. Systematic Development of Rhyming Skills in Earobics

a. Overview

Earobics teaches rhyming skills in two ways: 1) selecting rhyming words from a group of non-rhyming words and 2) selecting non-rhyming words from a group of rhyming words. Earobics builds auditory rhyming skills in a systematic step-by-step progression.

b. Rhyming Research Application in Earobics

1) Application in Earobics Step 1: The RhymeTime Game

RhymeTime, with 11 levels of play, is designed to teach rhyming, auditory performance with competing signals, auditory attention and auditory sequential memory skills.
2) Application in Earobics Step 2: The Duck Luck Game

Duck Luck, with 142 levels of play, teaches a variety of phonological awareness skills including sight recognition, auditory sequential memory, short term memory, phoneme identification, rhyming, auditory and phoneme discrimination, phonological blending, segmentation and manipulation, and word closure. Additional skills addressed in this game include: auditory attention, sound-symbol correspondence, short-term memory, phoneme sequencing, following oral directions, and comprehension of linguistic concepts. Learning variables, including the time interval between the sound segments and auditory interference, are controlled across levels of play.

Duck Luck begins with teaching recognition of common word endings that contain open syllable rimes (i.e., rimes that end in a vowel sound). The character Lyle Kyle Crocodile instructs the student to listen to various diphthongs\(^1\) and vowel digraphs\(^2\) (e.g., “oy,” “aw”). For example, the student hears three ducks saying words (e.g., “see,” “toy,” “chew”). The student clicks on the duck that says a word that ends with the “oy” sound. If the student responds correctly, the duck is turned over revealing a star underneath, and the student sees the printed letters of the word (e.g., “toy”). If the student responds incorrectly, the crocodile demonstrates the correct answer.

The training advances to teaching recognition of word beginnings with single consonants and consonant digraphs and progresses to two-consonant and three-consonant blends. As the training progresses, the complexity of syllable structure gradually increases in a step-by-step manner.

Once the student masters recognition of word endings and beginnings, the training progresses to teaching segmenting and deleting phonemes, onsets, and rimes. For example, the student hears “Which duck says ‘dog’ without the ‘d’?” The student selects the correct response from three choices, such as “at,” “ought,” “og.” When the student responds, (s)he also sees the printed letters of the word.

After the student masters blending onsets with rimes, Duck Luck progresses to teaching segmenting and deleting phonemes, onsets, and rimes. For example, the student hears “Which duck says ‘dog’ without the ‘d’?” The student selects the correct response from three choices, such as “at,” “ought,” “og.” When the student responds, (s)he also sees the printed letters of the word.

\(^1\)A diphthong is a speech sound that glides continuously from one sound to another in the same syllable (Nicolosi, 1989).

\(^2\)A diagraph is two letters written successively to represent one single sound (Nicolosi, 1989).

\(^3\)An onset is an initial consonant or initial consonant cluster in a word.
E. PHONOLOGICAL MANIPULATION

1. Research Summary
The ability to manipulate phonemes is strongly correlated with beginning reading acquisition.


2. Systematic Development of Phonological Manipulation Skills in Earobics

a. Overview
Earobics Step 2 provides extensive systematic instruction in phoneme manipulation, including substitution, omission, addition, repetition, and shifting of phonemes to make new patterns and words. Earobics carefully controls important learning variables, including the acoustic difference between sounds, the context in which sounds are presented, and the distinctiveness or saliency of sounds across levels of play.

b. Phonological Manipulation Research Application in Earobics

1) Applications in Earobics Step 2
Paint by Penguin, with 68 levels of play, also teaches phoneme manipulation skills including sequencing, insertion, deletion, and substitution of phonemes to make real and nonsense words. Other skill training includes auditory memory and sequential memory, auditory attention, auditory and phoneme discrimination, and phoneme segmentation.

The student first masters counting, sequencing and segmenting speech sounds in words with simple and complex syllable structure (see description under the Segmentation section, page 8). Paint by Penguin then progresses to teaching phoneme manipulation skills. The student is given the following instructions: “Allow me to paint the first word. Then, change the word I paint into another word. Use the same color for sounds that are the same; select any new color to paint a new sound.” The student hears a sound pattern and sees colored prints representing each sound. For example, the student may hear “This combination of sounds says ‘be’.” The student sees two colors (e.g., red, then blue), one for each sound. The student is then instructed to “change ‘be’ to ‘eeb’.” The student re-arranges the colors (e.g., blue, then red) to create a new nonsense word. By providing the student with a visual representation of sounds (i.e., the colored prints) the student strengthens skills in manipulating sounds. The game increases in difficulty, requiring the student to delete a phoneme from a word (e.g., changing “cat” to “ca”), replace a phoneme to create a new word (e.g., changing “dog” to “dig”), and insert a phoneme to make a new word (e.g. changing “tot” to “tots”).

Throughout the various levels of play, auditory feedback is first used and then faded to facilitate independent skill development.

The Pesky Parrots Game challenges the student’s application of phonological awareness skills through word closure tasks at the more advanced levels of the game. For a more detailed description of the game and its primary objectives and related skills, please refer to page 7 in the section on Blending Research.
A. DISCRIMINATION

1. Research Summary

The ability to perceive and discriminate speech sounds is foundational to the emergence of phonemic awareness.


2. Systematic Development of Discrimination Skills in Earobics

a. Overview

Earobics incorporates extensive speech discrimination activities that develop vowel and consonant discrimination skills in a systematic, adaptive training format. Earobics systematically presents sound pairs based on their acoustic properties. Earobics also incorporates state-of-the-art technology to acoustically modify the speech signal, making the signals for important parts of speech more distinctive. This facilitates the development of discrimination skills.

b. Discrimination Research Application in Earobics

1) Application in Earobics Step 1: Basket Full of Eggs Game

Basket Full of Eggs, with 114 levels of play, teaches auditory and phoneme discrimination, auditory attention, short-term memory, sequential memory, pattern recognition and temporal ordering. Additional skill training includes following oral directions and comprehension of linguistic concepts.

The training begins by pairing vowels that are separated by four or more steps on the acoustic continuum or those vowels that sound the most different (e.g., “ee” as in “knee” vs. “oo” as in “new”). The student is presented with two vowel sounds and is asked whether the sounds are the same or different. If the student is correct, (s)he catches an egg in Farmer Fardell’s basket. If the answer is incorrect, the egg drops and cracks. The training progresses in difficulty by presenting pairs of vowels that are more and more perceptually similar (e.g., “hood” and “who’d”).

2) Application in Earobics Step 2: The Hippo Hoops Game

Hippo Hoops, with 155 levels of play, teaches auditory and phoneme discrimination, auditory vigilance, phoneme identification, and phoneme sequencing. Additional skill training includes short-term memory, sound-symbol correspondence, following oral directions, comprehension of linguistic concepts, and auditory vigilance.

The training begins with an auditory vigilance task during which the student discriminates a change in the vowel phoneme of a minimal pair consonant/vowel/consonant (CVC) word. For example, the student hears a list of CVC words such as “bit, bit, bit, bit, bet.” The student listens for a change in the vowel of the CVC combination. When the student hears the change, (s)he lets go of the mouse; Hakeem Hippo shoots a ball in the basketball hoop and scores a banana point in the score box. If the student responds incorrectly, the ball goes to the other team, and the Rhinos get the point. The game progresses to vowel pairs that are more difficult to discriminate.

Once the student masters vowel discrimination, the training progresses to teaching discrimination of consonants in consonant-vowel syllables. At this level of play, computer-generated and acoustically-modified speech is utilized to facilitate the development of discrimination skills. Acoustic speech characteristics such as onset formant frequency (for liquids, nasals and stops) are carefully controlled across levels of play. The training begins with a pair of sounds that have a relatively large difference in formant onset frequency or voice onset time. As the student progresses, the acoustic difference is gradually reduced (in single steps along an 8-step continuum), challenging the student to make finer discriminations between the two sounds in the pair.
CV syllables. Computer-generated and acoustically modified speech is used to facilitate discrimination skills, controlling acoustic speech characteristics such as onset formant frequency (for fricatives, liquids, nasals and stops) and voice onset time (for stops).

After the student masters discrimination of vowels and consonants, the game progresses to different types of skill training. The next level of training teaches the student to recognize diphthongs in a word. For example, the student learns that the sound “i” as in “by” can be spelled “i,” “y,” “igh,” or “i-e.” Other tasks in Hippo Hoops include recognition of tense and lax vowels in a word and identification of the position of a consonant sound in a word.

Pesky Parrots, Calling All Engines and Paint By Penguin also address skill development in the student’s ability to discriminate among sounds. These are described on the corresponding pages listed below:
- Pesky Parrots (page 7)
- Paint By Penguin (page 9)
- Calling All Engines (page 16)

B. AUDITORY PERFORMANCE WITH COMPETING SIGNALS

1. Research Summary
Success in school requires a student to screen out distracting background noise and to learn to focus attention on the most important sounds.

Without the ability to maintain focus in the presence of background noise, a student will have difficulty attending to oral directions. This can potentially create frustration and reduced interest in learning.

2. Systematic Development of Auditory Performance with Competing Signals Skills in Earobics

a. Overview

Earobics teaches the skill of focusing on sound in the presence of background noise. Earobics systematically adds increasing background noise (e.g., none/low/high) competing for the student’s attention.

b. Research Application in Earobics

1) Application in Earobics Step 1: See Karloon’s Balloons (page 15) and RhymeTime (page 10) games

2) Application in Earobics Step 2: See Calling All Engines (page 16) game

C. AUDITORY SHORT-TERM MEMORY

1. Research Summary
   Students must be able to blend sounds separated by a two-second interval because decoding words requires two seconds to recognize the symbol, recall the sound, and hold and process the sound in auditory memory.


2. Systematic Development of Auditory Memory Skills in Earobics
   a. Overview

   Auditory short-term memory is the ability to retain sounds in auditory memory for the completion of a task.

   Earobics develops auditory memory in a step-by-step progression. Earobics systematically controls and extends the interstimulus interval from .25 to 2.0 seconds between sounds to gradually increase the amount of time that a student must hold a sound in auditory memory. Earobics also systematically fades visual cueing, thereby teaching the student to use pure auditory memory skills.

   b. Auditory Memory Research Application in Earobics

   1) Earobics Step 1: See Caterpillar Connection (page 7) and Karloon’s Balloons (page 15)

   2) Earobics Step 2: See Pesky Parrots (page 7) and Calling All Engines (page 16)

D. AUDITORY SEQUENTIAL MEMORY

1. Research Summary
   Students with reading problems have been found to perform poorly on memory span tasks for items with verbal labels.


   Auditory memory problems can lead to faulty comprehension. In reading new words, auditory memory of letter sounds must be automatic, and the student must be able to sequence the sounds.


   2. Systematic Development of Auditory Sequential Memory Skills in Earobics
   a. Overview

   Auditory sequential memory is the ability to remember sounds and words in sequential order. Earobics uses individualized adaptive training to develop and extend auditory sequential memory. The Earobics programs systematically lead children through a series of tasks, gradually increasing the number and complexity of different sounds and fading visual cueing to develop auditory sequential memory.

   b. Auditory Sequential Memory Research Application in Earobics

   1) Application in Earobics Step 1: The Karloon’s Balloons Game

   Karloon’s Balloons, with 38 levels of play, is designed primarily to teach auditory sequential memory, auditory attention, and auditory performance with competing signals. Additional skill training includes: auditory and phoneme discrimination, phoneme identification, spoken language processing, and sound-symbol correspondence.

   In this game four stimulus types are used to develop auditory sequential memory: environmental sounds, words, digits, and speech sounds. Karloon the clown asks the student to click on the picture of what he hears. Initially, the student hears one environmental sound and clicks on the corresponding picture. If the student is correct, Karloon’s balloon floats to the top of the screen. If the student is incorrect, the balloon pops, and the student is shown the correct response. If the student responds correctly three consecutive times, the program automatically adjusts and presents the student with two
sounds to recall in order. After the student can recall the sequence of two environmental sounds, the student hears three sounds and must recall them in order. If the student misses two in a row, the program adjusts backwards for additional training at the previous skill level.

Initially, pictures display simultaneously with the auditory presentation of the sounds. This allows the student to use visual cues to complete the task. As the student progresses, the visual display of the response choices is delayed, requiring the student to complete the task without the benefit of visual cueing.

After the student is successful in sequencing three environmental sounds with and without a simultaneous visual display, the game progresses to teaching sequential memory for words. The student progresses through a systematic and progressive sequence of skill training as outlined above, sequencing one up through four words in order, with and without visual cueing.

After the student successfully sequences four words with a delayed visual display, auditory figure-ground discrimination training begins. At this level, the student learns to focus his/her attention and process sounds in the presence of competing background noise. First low level circus crowd noise is introduced. When the student is successful, the volume of the background noise increases, further challenging the student.

Once the student masters auditory sequential memory for four words with no visual cueing in the presence of background noise, the student is presented with number stimuli to develop sequential memory for digits. The training progresses systematically as above, sequencing one to four numbers in order with and without visual cueing and with low and high-level background noise.

After the student masters sequential memory for four digits, the stimulus type changes to phonemes, requiring him/her to match sounds to letters. At this level, the student learns to sequence one to four phonemes with and without visual cueing and in no, low or high background noise.

2) Application in Earobics

Step 2: Calling All Engines Game

Calling All Engines, with 168 levels of play, systematically teaches auditory short-term and sequential memory, auditory attention, auditory performance with competing signals, following oral directions, and comprehension of linguistic concepts. Additional skill training includes: auditory and phoneme discrimination and sound-symbol correspondence.

In this game, five types of sounds are used to develop auditory sequential memory: digits, words, long vowels, short vowels, and consonant sounds. FireFighter Fly presents one item (i.e., digits, words, long vowels, short vowels or consonant sounds) and the student clicks on the picture of what (s)he hears. After the student identifies one of the sounds, (s)he learns to sequence two items, then three, four, and five items in order. When the student correctly sequences the items, FireFighter Fly sprays water to put out a fire, and the student receives a firefighter badge in the score box. If the student responds incorrectly, (s)he is given the correct response, and a fire hose appears in the score box.

Like Karloon’s Balloons, as the training progresses, the student completes the task with a delayed visual display of pictures. This means that while the student is listening to the auditory stimulus, (s)he cannot see the pictures. When it is time to respond, the pictures appear, and the student clicks on the appropriate items. By delaying presentation of the pictures, the student is required to rely on auditory memory only and cannot use visual cues to assist in task completion.

After the student is able to sequence five items in order, with and without visual cueing, (s)he learns to follow directions containing linguistic concepts. The directions contain the stimulus items (i.e., digits, words, long vowels, short vowels and consonant sounds) as well as linguistic concepts (e.g., before, after, and, or, not). For example, the student may be instructed to “click on ‘i’ before you click on ‘a’.” The student progresses through a series of tasks learning a variety of linguistic concepts in a sequential hierarchy of difficulty.

Once the student masters following directions with linguistic concepts, auditory figure-ground discrimination training begins. At this level, the student learns to follow directions in the presence of background noise. The volume of the background noise increases or decreases depending upon the student’s performance.