The Research Basis of Earobics

Phonological awareness is the key predictor of reading success.

More than two decades of research have proven that phonological awareness is essential to learning how to read. In fact, leading researchers have shown that phonological awareness is the most potent predictor 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 to incorporate the latest research and clinically proven training techniques. The result is a highly effective and engaging method for systematically developing the key skills that drive the ability to read and spell.

Defining phonological awareness

Phonological awareness is the ability to notice, think about or manipulate the sounds in language (Torgesen, 1997). The conscious manipulation of the sounds of speech means deleting, adding, or substituting syllables or sounds (i.e., /m/a/t/ says *mat*; change *mat* to *at*; now change *mat* to *cat*). If students cannot accurately recognize and manipulate speech sounds, they have difficulty relating the sounds of language to printed words, a skill essential to decoding words. If children cannot decode words quickly, they will have difficulty comprehending what they are reading.

Phonological awareness includes the following skills:

1. Rhyming
2. Phoneme identification
3. Blending
4. Segmentation
5. Manipulation

The skills typically emerge following a developmentally appropriate hierarchy (Figure 1). Early developing phonological awareness skills include rhyming and sentence segmentation, which reflect a gross awareness of the sounds of speech. Once children develop sensitivity to sounds, they learn that words are comprised of smaller units, such as syllables, and that these segments can be blended together or broken apart. As phonological awareness is further developed, children learn that words and syllables are made up of even smaller parts – individual sounds (called phonemes). The ability to manipulate these phonemes is the most challenging and latest developing phonological awareness skill.

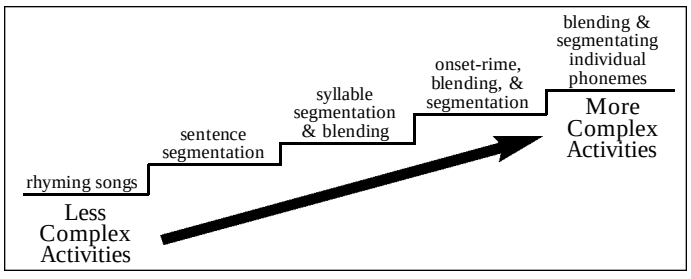

Figure 1. A continuum of complexity of phonological awareness activities.
✧ Chard, D. J.; Dickson, S.V. (1999). "Phonological Awareness: Instructional and Assessment Guidelines." *Intervention in School and Clinic*, 34 (5), p. 261-270.

There is still research to be done in determining normal growth rates for phonological awareness, but it is possible to outline some broad benchmarks of development for the early school years (Figure 2). It is worth noting, however, that average development in one school district may not be average in another. Phonological awareness at school entry varies substantially in children from different kinds of home and cultural backgrounds. Nevertheless, children who fall very far below the rate of development outlined in Figure 2 are likely to experience difficulties acquiring early reading skills.

At age:	The average child can:
Beginning kindergarten	Tell whether two words rhyme. Generate a rhyme for a simple word like *cat* or *dot*. Or be easily taught to do these tasks.
End of kindergarten	Isolate and pronounce the beginning sound in a word like *nose* or *fudge*. Blend the sounds in two-phoneme words like *boy* or *me*.
Midway through first grade	Isolate and pronounce all the sounds in two- and three-phoneme words. Blend the sounds in four-phoneme words containing initial consonant blends.
End of first grade	Isolate and pronounce the sounds in four-phoneme words containing initial blends. Blend the sounds in four- and five-phoneme words containing initial and final blends.

Figure 2. Expectations for the development of phonological awareness skills.
✧ Torgesen, J.K. & Mathes, P.G. (1998). "What Every Teacher Should Know About Phonological Awareness." Florida State University, Florida Department of Education.

What the research says about phonological awareness

- 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.
  - ✧ Stanovich, K. E., & Siegle, L.S. (1994). "Phenotypic performance profiles of children with reading disabilities: A regression-based test of the phonological-core variable-difference model." *Journal of Educational Psychology,* 86, p. 24-53.
  - ✧ Stanovich, K. E. (1986). "Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy." *Reading Research Quarterly,* 21, p. 360-407.

What is the difference between phonological and phonemic awareness?

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 is a reliable predictor of reading achievement and enables early identification of students at risk for difficulty in learning to read.
  - ✧ Christensen, C. A. (1997). "Onset, Rhymes and Phonemes in Learning to Read." *Scientific Studies of Reading,* 1 (4). p. 341 - 358.
  - ✧ Hurford, D. P.; Darrow, L. J.; Edwards, T. L.; Howerton, C. J.; Mote, C. R.; Schauf, J. D. & Coffey, P. (1993). "An examination of phonemic processing abilities in children during their first-grade year." *Journal of Learning Disabilities,* 26 (3), p. 167-177.
  - ✧ Mann, V. (1993). "Phoneme awareness and future reading ability." *Journal of Learning Disabilities,* 26, (4), 259-269.
  - ✧ Cornwall, A. (1992). "The relationship of phonological awareness, rapid naming and verbal memory to severe reading and spelling disability." *Journal of Learning Disabilities,* 25, (8), p. 532-538.

- 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.
  - ✧ Moats, L. C. & Foorman, B. R. (1997). "Introduction to the special issue of SSR: Components of effective reading instruction." *Scientific Studies of Reading* 1 (3), p. 187-189.
  - ✧ Adams, M. (1990). *Beginning to Read: Thinking and Learning About Print.* Cambridge, MA: MIT Press.

- 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.
  - ✧ Morais, J.; Mousty, P. & Kolinsky, R. (1998). "Why and how phoneme awareness helps learning to read." In C. Hulme and R. M. Joshi (Eds.), *Reading and Spelling: Development and Disorders.* Mahwah, NJ: Lawrence Erlbaum, Asc., p. 127 - 152.
  - ✧ Spector, J. (1995). "Phonemic awareness training: Application of principles of direct instruction." *Reading & Writing Quarterly,* 11, p. 37-51.
  - ✧ Ball, E. W. & Blachman, B. A. (1991). "Does phoneme awareness training in kindergarten make a difference in early word recognition and developmental spelling?" *Reading Research Quarterly,* 24, (1), p. 49-66.
  - ✧ Liberman, I. Y. & Shankweiler, D. (1991). "Phonology and Beginning Reading: A Tutorial." In L. Rieben and C. A. Perfetti (Eds.), *Learning to Read: Basic Research and Its Implications.* Hillsdale, NJ: Lawrence Erlbaum, Publishers.
  - ✧ Adams, M. (1990). *Beginning to Read: Thinking and Learning About Print.* Cambridge, MA: MIT Press.
  - ✧ Byrne, B. & Fielding-Barnsley, R. (1989). "Phonemic awareness and letter knowledge in the student's acquisition of the alphabetic principle." *Journal of Educational Psychology,* 81, p. 313-321.
  - ✧ Vellutino, F. R. & Scanlon, D. M. (1987). "Linguistic coding and reading ability." In S. Rosenberg (Ed.), *Advances in Applied Psycholinguistics* (2) p. 1-69. New York: Cambridge University Press.
  - ✧ Stanovich, K. E. (1985). "Explaining the variance in reading ability in terms of psychological processes: What have we learned?" *Annals of Dyslexia,* 35, p. 67-96.

- 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.
  - ✧ Christensen, C. A. (1997). "Onset, rimes and phonemes in learning to read." *Scientific Studies of Reading,* 1 (4), p. 341 - 358.
  - ✧ Fitzpatrick J. (1997). *Phonemic Awareness, Playing with Sounds to Strengthen Beginning Reading Skills.* Creative Teaching Press. Cypress, CA.
  - ✧ Ball, E. W. & Blachman, B. A. (1991). "Does phoneme awareness training in early kindergarten make a difference in early word recognition and developmental spelling?" *Reading Research Quarterly,* 26 (1), p. 49 - 66.
  - ✧ Ehri, L. C.; Barron, R. W. & Feldman, J. M. (1978). *The Recognition of Words.* Newark, DE: International Reading Association.

The road to literacy

Cognitive Concepts looks at phonological awareness as a step in the language-to-literacy model of learning to read (Figure 3). The skills represented in each step are foundational to the next, while at the same time reciprocal and overlapping.

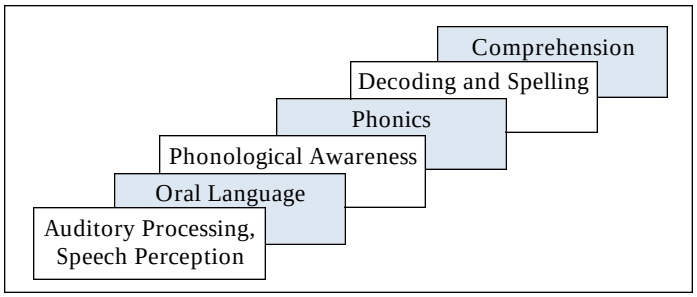

Figure 3. The Language to Literacy model of learning to read.

Auditory processing skills, including speech perception, are innate and automatic auditory skills that allow us to understand and develop oral language. Auditory processing and oral language are the foundational skills for the later development of phonemic awareness. Phonological awareness is the key to transitioning from oral to written language and is a hallmark of good readers. Some students with reading problems have underlying deficits in auditory processing and speech perception skills. Many students with reading problems have deficits in phonological awareness skills.

Phonics is the ability to make linkages between discreet phonemes and individual letters. Fully developed phonological awareness skills and knowledge of the alphabetic principle (phonics) are required for successful decoding, which is translating individual letters into sounds to access the pronunciation of words. Comprehension is the end goal – the ability to extract meaning from written text. Comprehension requires fluent and accurate decoding.

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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How phonological awareness research is applied in Earobics

1. Rhyming

- 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.

- ✧ Goswami, U. (1993). "Toward an Interactive Analogy Model of Reading Development: Vowel Graphemes in Beginning Reading." *Journal of Experimental Student Psychology,* 54, p. 443-475.
- ✧ Maclean, M.; Bryant, P. & Bradley, L. (1987). "Rhymes, nursery rhymes, and reading in early childhood." Merrill-Palmer Quarterly. 33, p. 255-281.
- ✧ Goswami, U. (1986). "Children's use of analogy in learning to read: A developmental study." *Journal of Experimental Student Psychology,* 42. Performance on rhyme and alliteration detection tasks is related to success in beginning reading.
- ✧ Treiman, R. (1985). "Onsets and rimes as units of spoken syllables: Evidence from children." *Journal of Experimental Student Psychology,* 25, p. 476-491.
- ✧ Bryant, P. E. & Bradley, L. (1980). In U. Frith (Ed.), *Cognitive Processes in Spelling,* p. 311 - 338. San Diego, CA: Academic Press.
- ✧ Liberman, I. Y.; Shankweiler, D.; Fischer, F. W. & Carter, B. (1974). "Explicit syllable and phoneme segmentation in the young student." *Journal of Experimental Student Psychology,* 18, p. 201-212.

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.

2. Phoneme Identification

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

- ✧ Lyon, G. R. (1998). Learning to Read: "A Call from Research to Action" From statements made before the Committee on Education and the Workforce, U.S. House of Representatives, Washington, D.C., July 10, 1997.
- ✧ Juel, C.; Griffith, P. L. & Gough, P. B. (1986). "Acquisition of literacy: A longitudinal study of children in first and second grade." *Journal of Educational Psychology,* 78, p. 243 -255.

- 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.

- ✧ Burgess, S. R., & Lonigan, C. J. (1998). "Bidirectional relations of phonological sensitivity and pre-reading abilities: Evidence from a preschool sample." *Journal of Experimental Child Psychology,* 70, p. 117 - 141.
- ✧ Snow, C.; Burns, S. & Griffin, P. (1998). *Preventing Reading Disabilities in Young Children.* Washington, DC: National Academy Press.

- Before children are able to map printed letters to sounds in spoken language, they must be able to identify those sounds accurately.

- ✧ Fitzpatrick, J. (1997). *Phonemic Awareness, Playing with Sounds to Strengthen Beginning Reading Skills.* Creative Teaching Press. Cypress, CA.
- ✧ Nation, K. & Hulme, C. (1997). "Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills." *Reading Research Quarterly,* 32 (16), p. 154 - 167.
- ✧ Ehri, L. C. (1992). "Reconceptualizing the development of sight word reading and its relationship to decoding." In Gough, P.; Ehri, L. C. & Treiman, R. (Eds.), *Reading Acquisition.* Hillsdale, NJ: Lawrence Erlbaum, Publishers.
- ✧ Invernizzi, M. (1992). "The vowel and what follows: A phonologic frame of orthographic analysis." In S. Templeton & Bear, D. R., (Eds.), *Development of Orthographic Knowledge and the Foundations of Literacy.* p. 105-136.
- ✧ LaBerge, D. & Samuels, S. J. (1974). "Toward a theory of automatic information processing in reading." *Cognitive Psychology,* 6, p. 293-323.

Earobics teaches phoneme identification following a systematic hierarchy based upon the principles of speech acoustics, phonetics and speech perception. It 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.

3. Blending

- Phoneme synthesis (blending individual sounds together) and analysis are critical prerequisites for the attainment of early reading skills.

- ✧ Fitzpatrick, J. (1997). *Phonemic Awareness, Playing with Sounds to Strengthen Beginning Reading Skills.* Creative Teaching Press. Cypress, CA.
- ✧ Griffith, P. & Olson, M. (1992). "Phonemic awareness helps beginning readers break the code." *The Reading Teacher,* 45, p. 516-523.
- ✧ Torgesen, J.K. & Morgan, S. (1990). "Phonological synthesis tasks: A developmental, functional, and componential analysis." In H.L. Swanson and B. Keogh (Eds.). *Learning Disabilities: Theoretical and Research Issues.* Hillsdale, NJ: Erlbaum Assoc.
- ✧ Bradley, L. & Bryant, P. (1985). *Rhyme and Reason in Reading and Spelling.* Ann Arbor: University of Michigan Press.
- ✧ Perfetti, C.A.; Beck, I.; Bell, L. & Hughes, C. (1981). "Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children." *Merrill-Palmer Quarterly,* 33, p. 283-319.

Earobics Step 1 and Earobics Step 2 provide comprehensive sequential training of phonological blending skills following a developmentally appropriate hierarchy including blending words into compound words, syllables into words, and phonemes into words. Earobics carefully controls factors that facilitate learning, including the perceptual similarity of response choices and the timing between the sound segments.

4. Segmentation

- 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.

- ✧ Nation, K. & Hulme, C. (1997). "Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills." *Reading Research Quarterly,* 32 (16), p. 154-167.
- ✧ Rack, J. P.; Snowling, M.J. & Olson, R.K. (1992). "The nonword reading deficit in developmental dyslexia: A review." *Reading Research Quarterly,* 27, (1), p. 29-52.
- ✧ Adams, M. (1990). *Beginning to Read: Thinking and Learning About Print.* Cambridge, MA: MIT Press.
- ✧ Lenchner, O.; Gerber, M. M. & Routh, D. K. (1990). "Phonological awareness tasks as predictors of decoding ability: Beyond segmentation." *Journal of Learning Disabilities,* 23, (4), p. 240-247.
- ✧ Stanovich, K. E. (1988). "Explaining the differences between the dyslexic and the garden-variety poor reader: The phonological-core variable-difference model." *Journal of Learning Disabilities,* 21, p. 590-612.
- ✧ Vellutino, F. R. & Scanlon, D. M. (1987). "Linguistic coding and reading ability." In S. Rosenberg (Ed.), *Advances in Applied Psycholinguistics,* 2, p. 1-69. New York: Cambridge University Press.
- ✧ Stanovich, K. E. (1986). "Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy." *Reading Research Quarterly,* 21, p. 360-407.
- ✧ Stanovich, K. E. (1985). "Explaining the variance in reading ability in terms of psychological processes: What have we learned?" *Annals of Dyslexia,* 35, p. 67-96.

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.

How is phonological awareness different 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.

5. Phonological Manipulation

- The ability to manipulate phonemes is strongly correlated with beginning reading acquisition.
  - ✧ Fitzpatrick, J. (1997). *Phonemic Awareness, Playing with Sounds to Strengthen Beginning Reading Skills.* Creative Teaching Press. Cypress, CA.
  - ✧ Yopp, H. K. (1988). "The validity and reliability of phonemic awareness tests." *Reading Research Quarterly,* 23, p. 159-177.
  - ✧ Perfetti, C. A.; Beck, I.; Bell, L. C. & Hughes, C. (1987). "Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children." *Merrill-Palmer Quarterly,* 33 (3), p. 283 - 319.
  - ✧ Calfee, R. C.; Lindamood, C. & Lindamood, P. (1973). "Acoustic-phonetic skills and reading. Kindergarten through twelfth grade." *Journal of Educational Psychology64* (3).

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.

How auditory processing research is applied in Earobics

Discrimination

- The ability to perceive and discriminate speech sounds is foundational to the emergence of phonemic awareness.
  - ✧ Friel-Patti, S. (1998). "Implications of Auditory Processing on Emergent Literacy." American Speech Language Hearing Association Division 1 Newsletter: *Language Learning and Education*. p. 25-26.
  - ✧ Post, Y. V.; Foorman, B. R. & Hiscock, M. (1997). Speech perception and speech production as indicators of reading difficulty. *Annals of Dylsexia,* 47, p. 3-27.
  - ✧ Johnson, D. J. & Myklebust, H. R. (1967). *Learning Disabilities: Educational Principles and Practices.* Austin, TX: PRO-ED.

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 and phonetic 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.

Auditory Performance with Competing Signals

- 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.
  - ✧ Gillet, P. (1993). *Auditory Processes* (revised edition). Novato, California: Academic Therapy Publications.

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.

Auditory Short-Term Memory

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

- 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.
  - ✧ Booth, J. R.; Perfetti, C. A. & McWhinney, B. (1999). "Quick, automatic and general activation of orthographic and phonological representations in young readers." *Developmental Psychology,* 35 (1), p. 3-19.
  - ✧ Hegge, T.G.; Kirk, S. & Kirk, W. (1955) *Remedial Reading Drills.* Ann Arbor, Michigan: George Wahr Publishing.

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 auditory memory skills.

Auditory Sequential Memory

Auditory sequential memory is the ability to remember sounds and words in sequential order.

- Students with reading problems have been found to perform poorly on memory span tasks for items with verbal labels.
  - ✧ Shankweiler, D. & Liberman, I.Y. (1989). *Phonology and Reading Disability.* Ann Arbor: University of Michigan Press.
- 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.
  - ✧ Gillet, P. (1993). *Auditory Processes* (revised edition). Novato, California: Academic Therapy Publications.

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.

Cognitive Concepts is dedicated to developing innovative, research-based educational solutions for language and literacy. To learn more about our products and services, call us toll-free at 1-888-328-8199 in the U.S., or 1-847-328-8099 from outside the U.S. Or visit us at www.cogcon.com.

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