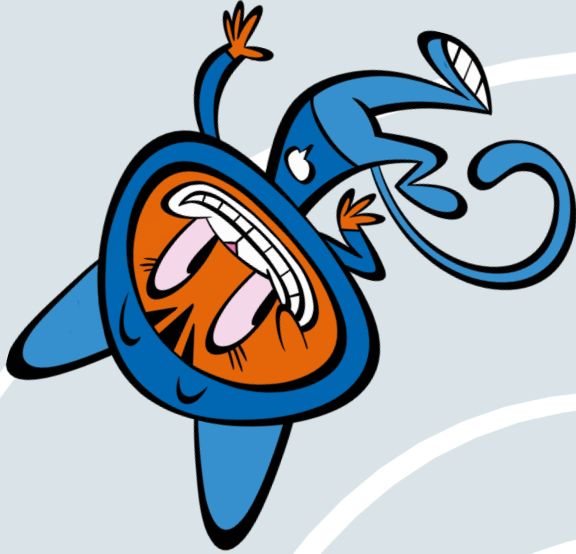
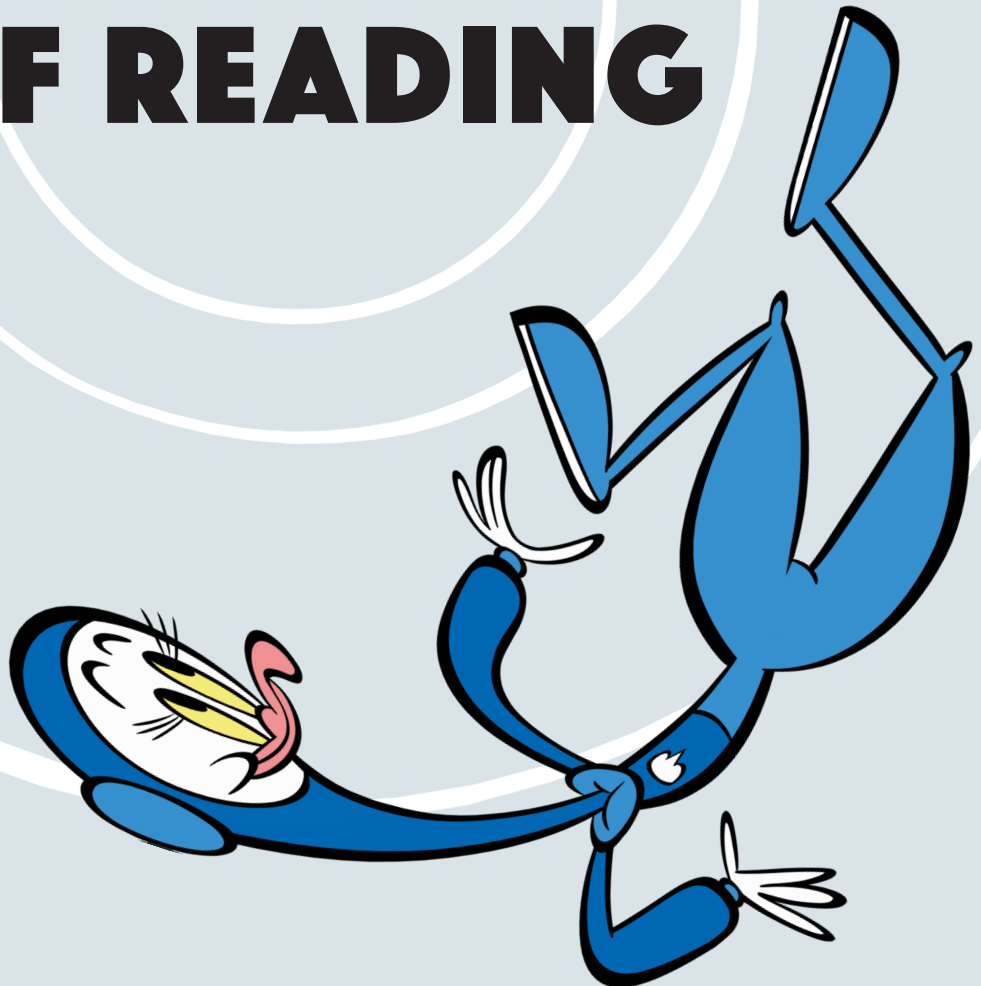


Mrs Wordsmith®



THE SCIENCE OF READING





INTRODUCTION

Mrs Wordsmith has created this white paper on the science of reading to share with parents and educators. This report demonstrates the important connection between how the brain learns to read (*the Neuroscience of Reading*) and how we teach children to read (*the Science of Reading Instruction*). It provides an overview of decades of academic research into how the brain learns to read and best practice on reading instruction. This is also based on findings by the National Reading Panel (US) and the Letters and Sounds Report on Phonics (UK).¹²

Our work aligns with the research of highly regarded academics and literacy experts such as Prof. Susan Neuman (NYU), Prof. Tim Shanahan (University of Illinois), and the work of leading neuroscientists such as Maryanne Wolf, author of the New York Times Bestseller *Reader Come Home: The Reading Brain in the Digital Age*, and Stanislas Dehaene, cognitive neuroscientist and author of *Reading in the Brain*.

THE NEUROSCIENCE OF READING

Reading, unlike speaking, is not hardwired into our brains when we are born. The reading process is neither natural nor automatic — it is a learned skill. While humans have used spoken language for roughly 60,000 years, the first examples of written language date back to only about 5,000 years ago. In evolutionary terms, the human brain has not had the same time to develop functional areas dedicated to reading.

Reading and writing are therefore man-made conventions, not biological ones. While we are biologically wired to hear sounds and notice images, we are not wired to decode written words (the key process behind reading). To become readers, our brains have to develop new neural networks that support reading and writing. The reading process itself is a result of the brain's neuroplasticity, or the ability to restructure and redirect existing neural networks to create new ones dedicated to learning something new. The process of rewiring the brain takes place throughout our lives but is critical during early development from ages 0-8.

Interestingly, learning to read varies by individual and culture. The brain develops neural networks based on specific tasks. When it comes to reading, our neural networks are developed by what we read and the written symbols we use. Thus, someone who reads Chinese characters has a slightly different neural network than someone who reads alphabetic characters like English or Arabic.³



HOW READING DEVELOPS IN A CHILD'S BRAIN

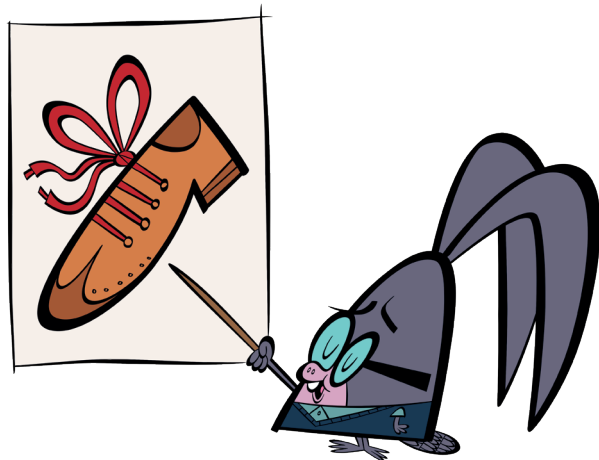
Since humans are not hard-wired to read, children must put extra effort into learning how to read and write. So it's easy to understand why many children struggle! A child has to train their brain to connect spoken language circuits with learned image circuits. These newly forged connections between letters and sounds create neural networks that enable us to read. What is critical is that students have repeated exposures to these new connections to solidify the circuitry in their brain.

In short, reading is a connection that occurs in the brain between oral language or sounds and visual representation or letters. When we read, our brains map information from oral language onto information of letters received from the visual system.⁴

Broken down into individual steps, the process of reading involves:

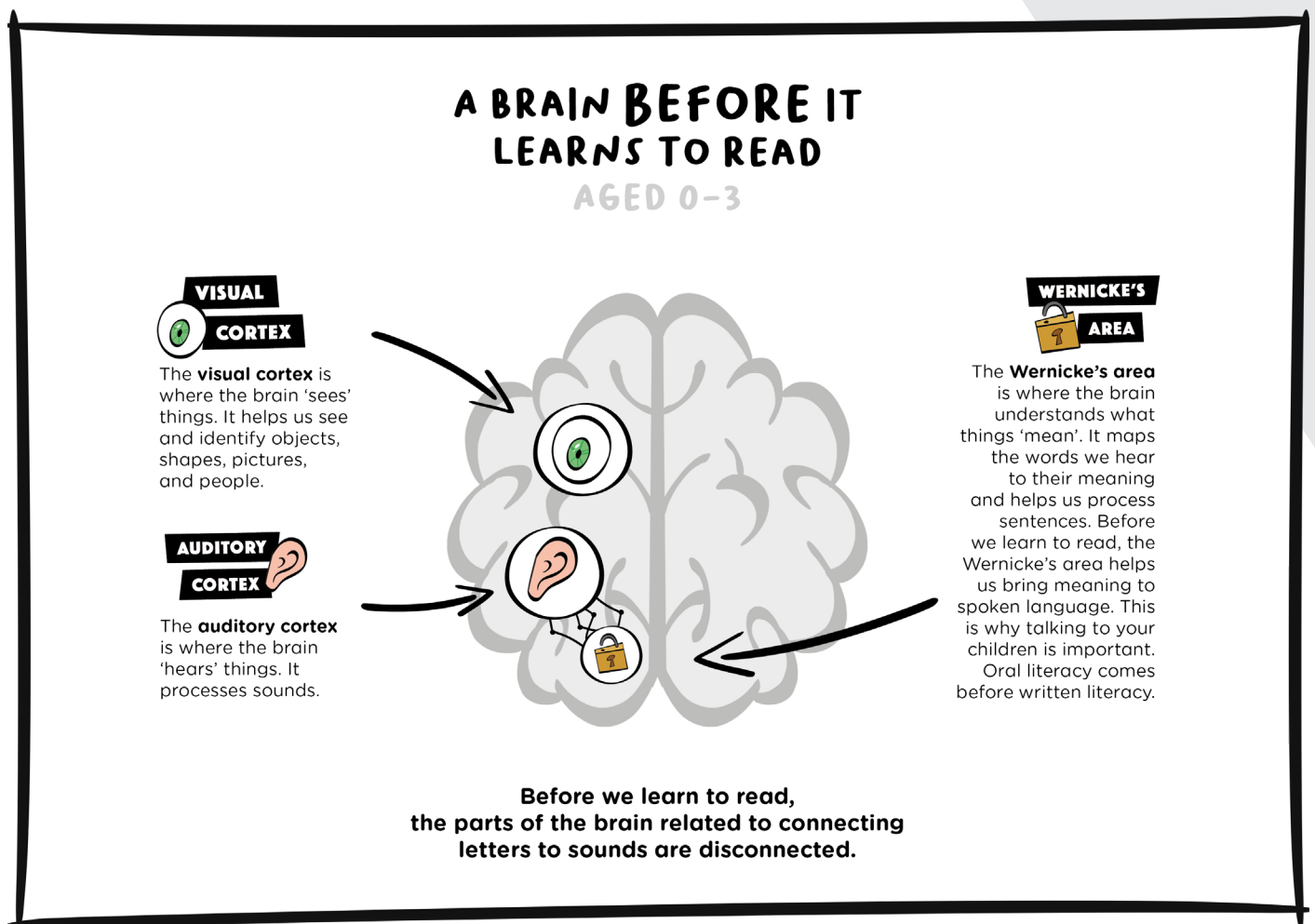
- 1 Identifying letters and noticing how they are combined into a unit known as a word.
- 2 Connecting these letters to their corresponding sounds (as if hearing a voice pronouncing them in our brain).
- 3 Connecting the word to its corresponding meaning.

Over time, this process becomes automatic. But given how complex this process is, we should not underestimate how challenging it is for children's brains to develop fluent reading skills. Reading is a complex neurophysiological process that requires systematic training and practice. Without practice and high-quality instruction, children's brains will not learn to conduct this process automatically.

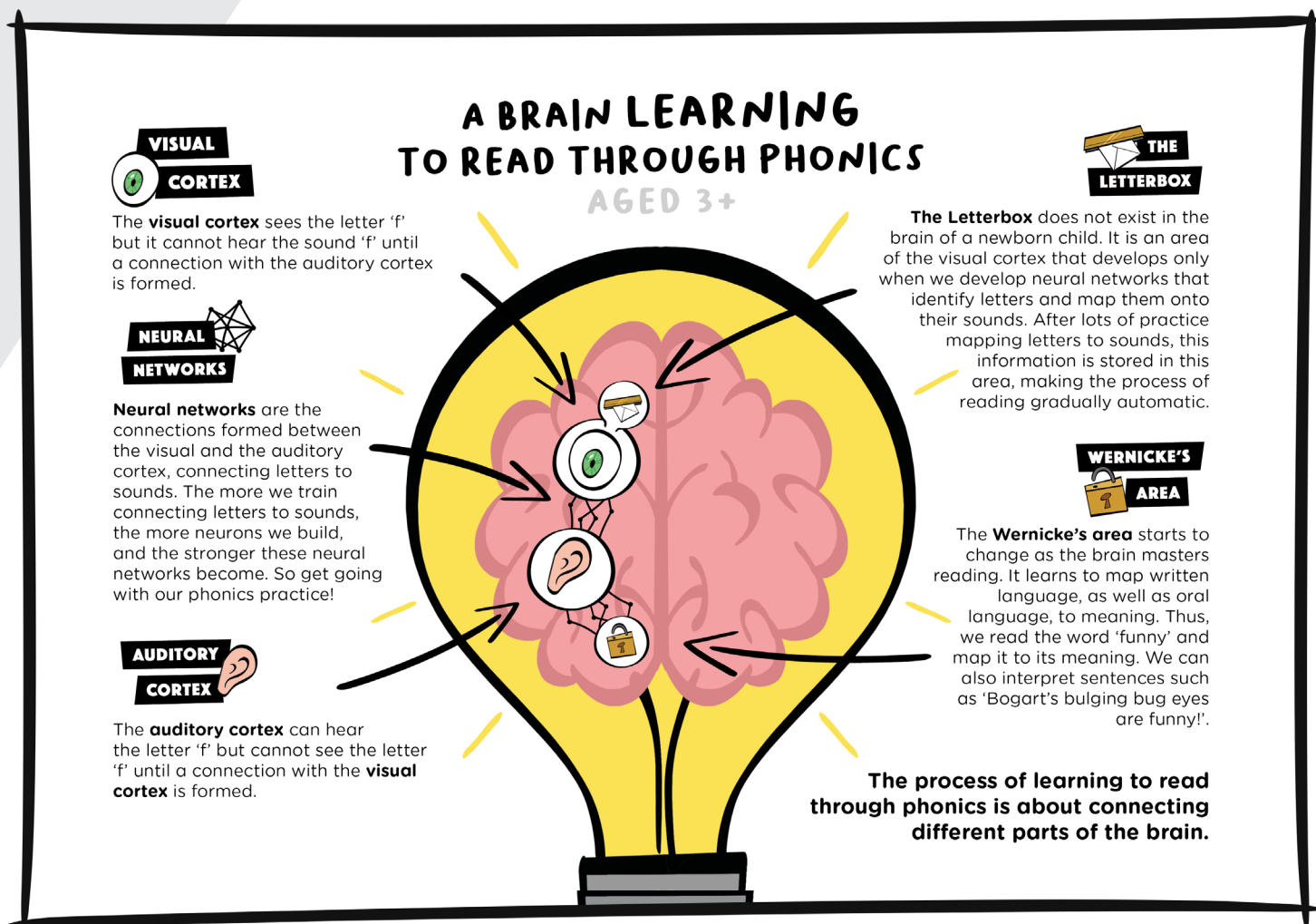


A CLOSER LOOK INSIDE THE BRAIN WHEN READING

Below is a diagram of the brain before a child learns to read. The parts of the brain that process letters (the visual cortex) are disconnected from the parts of the brain that process sounds (the auditory cortex). At this stage, the brain is capable of understanding the words it hears, but not the words it sees.



To read words, a child's brain needs to develop new neural networks that connect the visual cortex with the auditory cortex. It needs to connect the letter it 'sees' to the sound it 'hears'. For example, when the visual cortex sees the letter 'f' and the auditory cortex hears the sound 'f' as in 'funny', a new connection is formed. Every time a child decodes a new word, a new connection between the visual cortex and the auditory cortex is formed.

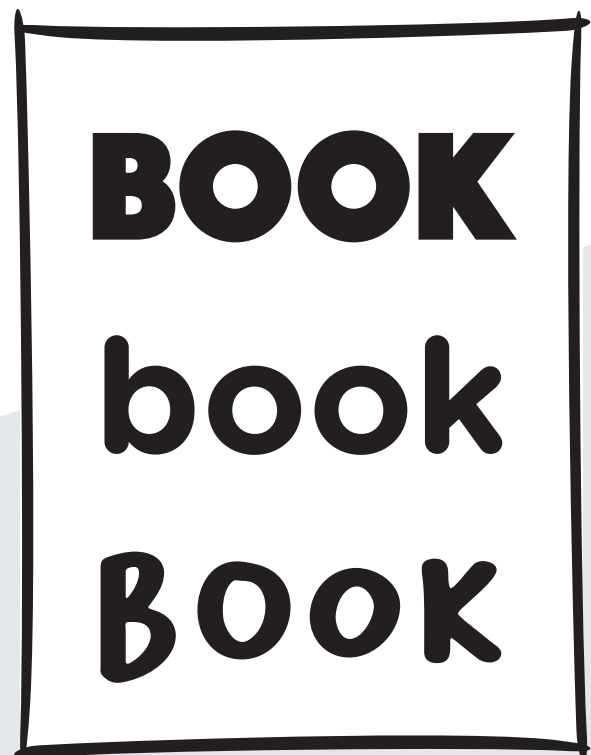


The ability to map letters to sounds has a significant impact on brain development. That's why learning phonics helps build the neural networks required for fluent reading. Above is a diagram of the brain learning to read through phonics. The brain has developed new areas.

The process of decoding words or blending letters into whole words sends information to *the letterbox*, an area of the visual cortex dedicated to written words. This area only develops when we are beginning to read and does not exist in very young children or illiterate adults. Information about the shapes of letters travels to *the letterbox* region of the brain. Here it is mapped onto information about sounds and meanings. *The letterbox* is also responsible for sophisticated tasks that are essential for a fluent reader. This includes acknowledging that 'BOOK' and 'book' are the same word, whether written in upper case, lower case, or handwritten.⁴

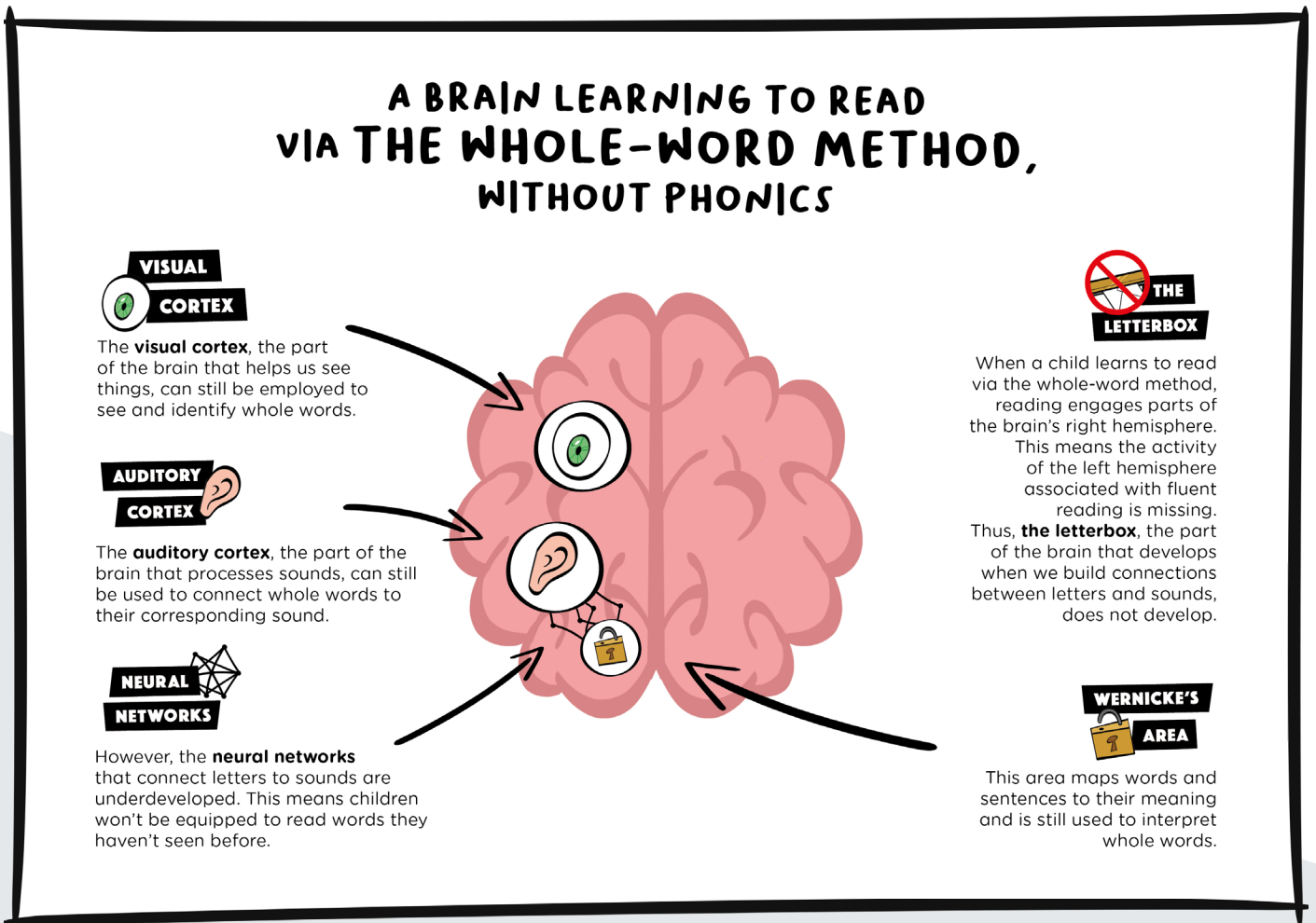
For a child learning to read, the process of mapping letters to sounds is slow and laborious.

With time, it becomes automatic. Learners need to encounter words again and again in order to start identifying them instantly, without having to decode each one letter by letter. But the process of associating letters to sounds that is achieved with phonics is much more beneficial for the brain of a reader than learning how to read via the *whole-word method*.



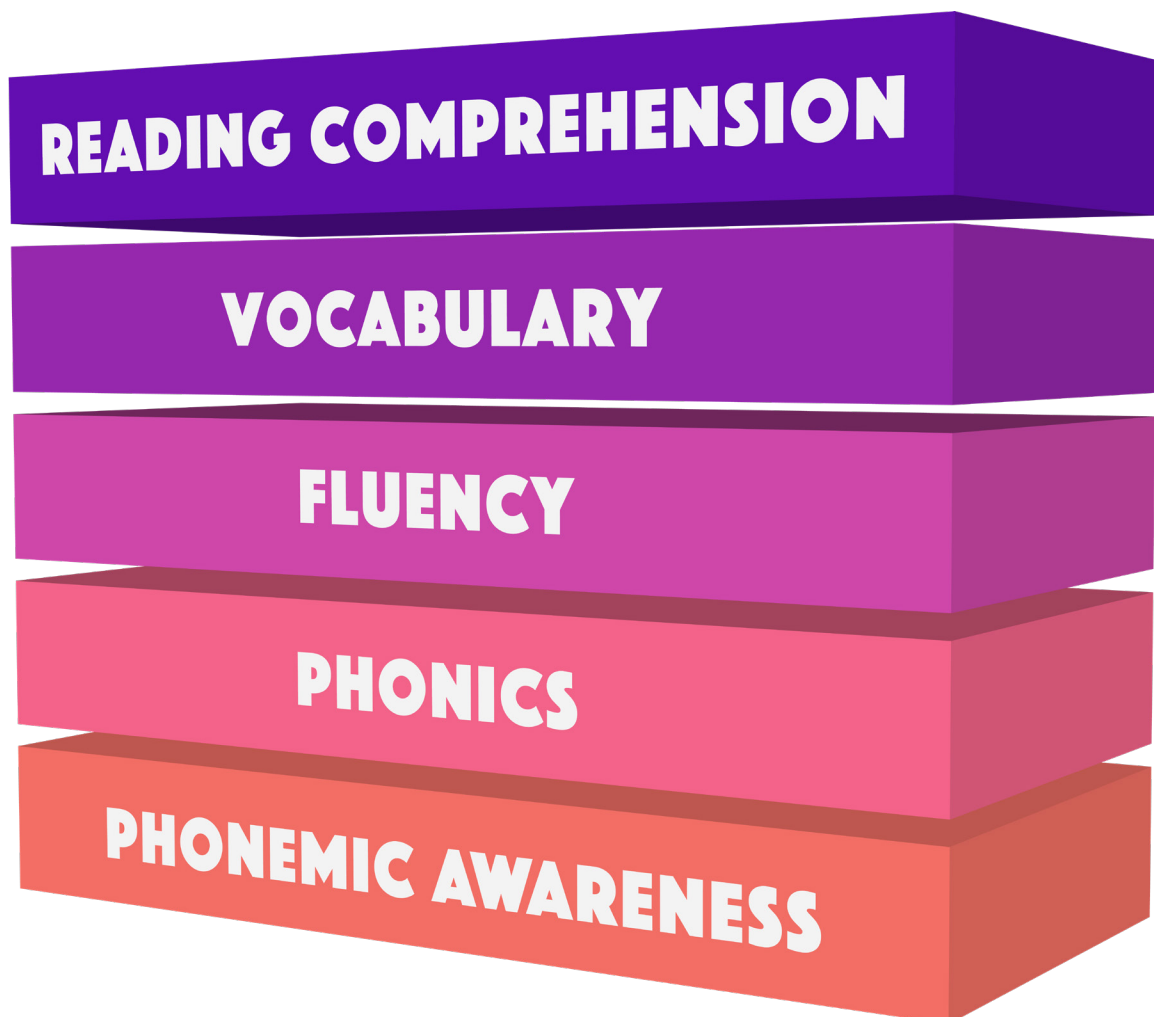
Below is a diagram of a brain learning to read via the *whole-word method*, without phonics. The *whole-word method* is learning the form of whole words by heart. This doesn't build the same circuitry between the learner's auditory cortex and visual cortex. This means readers with no knowledge of phonics have an underdeveloped ability to connect letters to sounds and never develop *the letterbox* area of the brain. These readers do not reach the same level of automaticity and are underprepared to decode unfamiliar words. This has a significant impact on reading fluency.

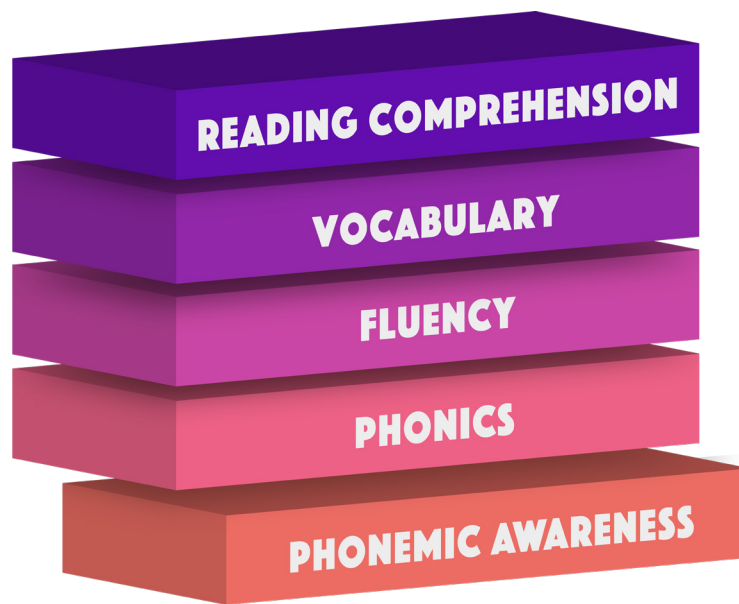
Studies have identified certain patterns of activity that occur in the left brain hemispheres of fluent readers. One study comparing the neural activity of a fluent reader to that of an individual learning to read found that learners using phonics showed high levels of activity in the brain's left hemisphere. This resembled the brain activity of fluent readers. Learners who used the *whole-word method* demonstrated no activity of this kind — showing that *how* we learn to read matters.



THE FIVE BUILDING BLOCKS OF READING

Phonics is one of the five science-based building blocks of reading. The skills listed below support the gradual process through which children learn to read.





The ability to identify and manipulate the individual sounds (phonemes) that make up spoken words.

This is the first skill that children must master when learning how to read. It helps them to 'hear' and 'see' the connections between sounds and letters. It is one of the most important factors in determining a child's future reading success.

Phonemic awareness can be built through exercises that ask children to identify the first phoneme in a word, or rhyming

activities that help children understand that words such as 'cat', 'bat', and 'hat' differ only in their first phoneme. It is also built through teaching children to blend and segment individual sounds in spoken words. For example, putting together 'c'- 'a'- 't' to make 'cat' (blending) and breaking down 'cat' into 'c'- 'a'- 't' (segmenting).

c-a-t

Phonemic awareness is identifying and manipulating the individual sounds that make up spoken words. This is the first skill that children must master when learning how to read because it enables them to match sounds to letters later on. It is one of the most important factors in determining a child's future reading success. Children who lack phonemic awareness have greater difficulties learning to read.

It is easy to confuse phonemic awareness with the terms phonological awareness and phonics.

- Phonological awareness is the broader awareness of sounds in language and is also important when learning how to read. It involves identifying individual words in a sentence or breaking words down into syllables (as in, sil-ly).
- Phonemic awareness refers to identifying individual sounds or phonemes (the smallest units of sound like /f/) in spoken words.
- Phonics describes the connection between sounds and letters.

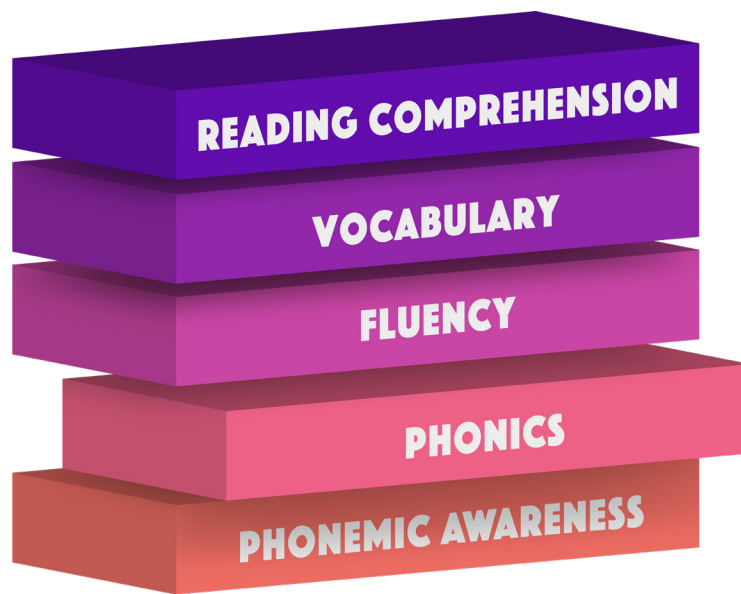
Phonemic awareness is a building block for phonics, as children cannot learn to associate letters and sounds without first being able to perceive distinct sounds in spoken language. Thus we 'hear' reading, before we 'see' it.

When a child is familiar with the sounds that make up the word 'rabbit,' they are more likely to quickly recognize the letters that correspond to the sounds in print.

This is why focusing on learning and understanding sounds is important. When teaching phonemic awareness, teachers show students how to hear, identify, and manipulate individual sounds in words. As children develop an awareness of the sounds made by spoken words, they also develop an awareness of the way words are constructed, which will help them in both reading and spelling. In school, children will encounter phonemic awareness exercises, like learning about rhyming words, to show how the sounds in different words are related. For example, in the words 'cat', 'hat', and 'bat', only one of the three sounds is different.

b-a-t

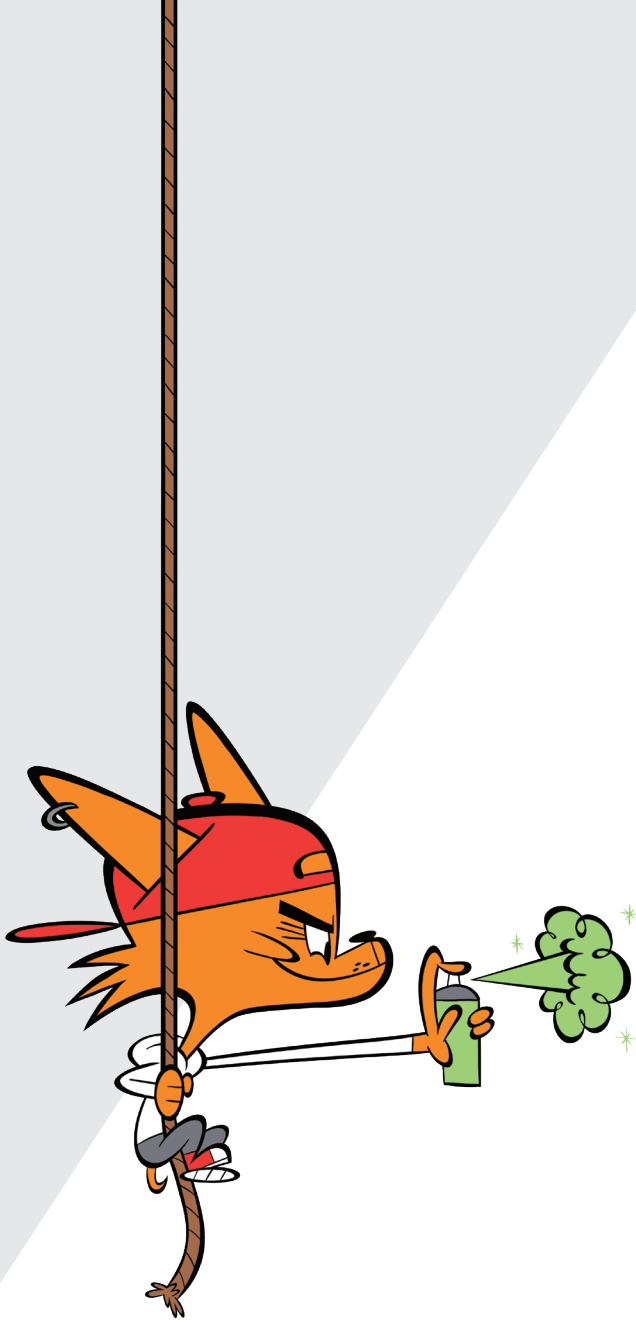




The process of systematically mapping phonemes (speech sounds) onto graphemes (letters and letter combinations).

Through systematic synthetic phonics instruction, children learn the sounds that different graphemes make in a structured way, progressing from the most common to the most rare. For example, f, ff, ph, and gh all make the sound /f/, but f and ff are more common than the others.

Children also learn the different ways in which a sound can be spelled, for example, *play* and *make* have the same vowel sound written using two different graphemes. Phonics instruction is critical to early brain development.



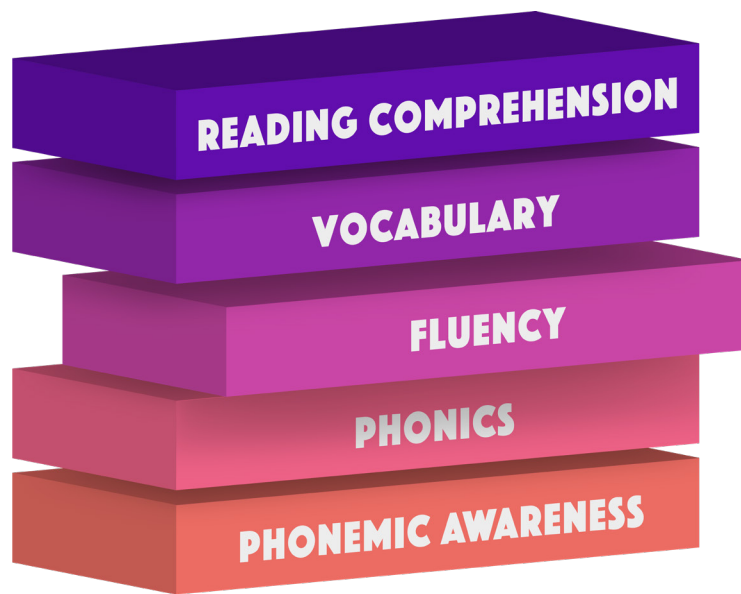
Phonics builds on phonemic awareness. Phonics is the process of systematically mapping **phonemes** (speech sounds) onto **graphemes** (letters and letter combinations).

Through systematic synthetic phonics instruction, children learn in an orderly manner the sounds that different graphemes make from the most common to the most rare. For example, *f*, *ff*, *ph*, and *gh* all make the sound /f/, but *f* and *ff* are more common than the rest. They also learn the different ways in which a sound can be spelled, for example, *play* and *make* have the same vowel sound written using two different graphemes.

Through phonics instruction, students interact with words in two ways: blending them and segmenting them. When you break down a word into individual sounds, it is called segmentation. When you take the individual sounds and put them together to make a word, it is called blending. Studies indicate that **systematic synthetic phonics** improves students' ability to read and spell words, especially amongst beginning and early readers (e.g. students in Kindergarten and First Grade (US) and students in Reception and Year 1 (UK)). Phonics instruction teaches children how to sound out words by learning sounds (phonemes) and letter (graphemes) correspondence. For a more detailed account of phonics instruction, see **Phonics Deep Dive**.

Phonics Deep Dive

https://cdn.shopify.com/s/files/1/1888/7469/files/Phonics_Deep_Dive_US.pdf?v=1607091482



The ability to read accurately, rapidly, and with expression.

A fluent reader moves through a text at a fluid pace, while simultaneously feeling and comprehending the meaning of the text.

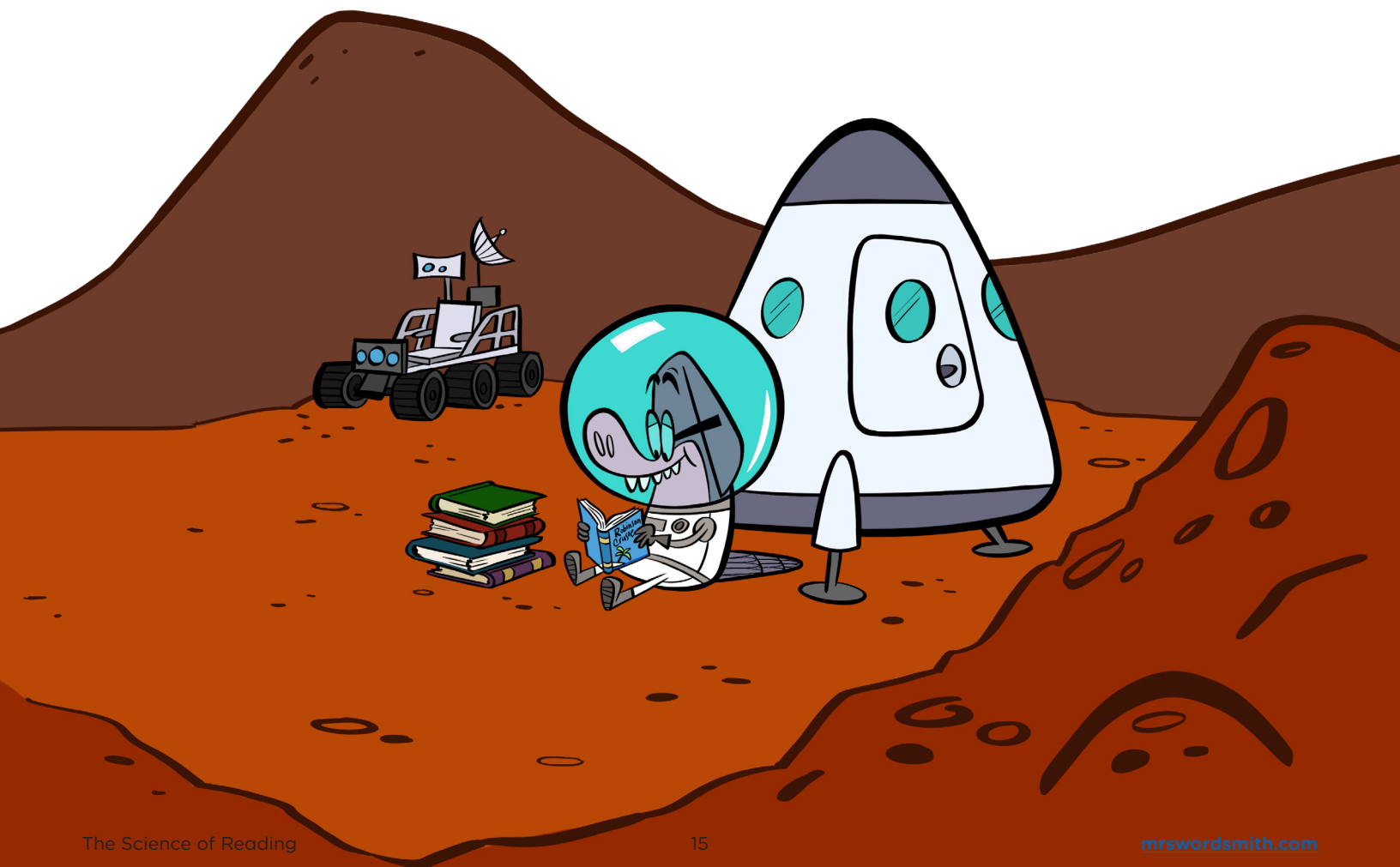
Teachers typically measure fluency through oral reading. But good readers also read with accuracy and expression when they read silently or “in their heads.”

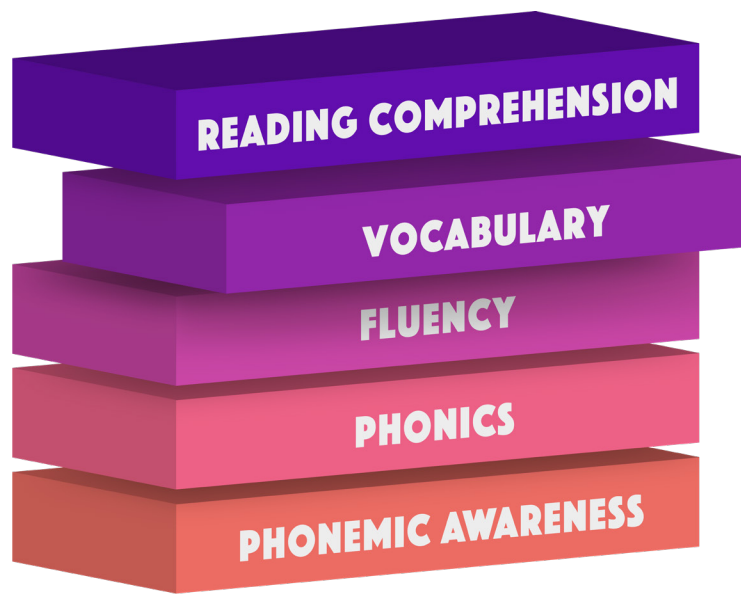
Readers who lack fluency are often still struggling with decoding. Lack of fluency may impact your child’s reading progression at school. You can work on this skill by reading aloud with expression for 10-15 minutes a day.

Reading fluency refers to reading accurately, rapidly, and with expression. A fluent reader moves through text at a fluid pace, while simultaneously feeling and comprehending the meaning of the text. Fluency brings reading “to life” for young readers.

Teachers typically measure fluency through oral reading. But good readers also read with accuracy and expression when they read silently or “in their heads.” They “hear” the characters “speak” with expression. They move rapidly through exciting texts to find out what happens next.

Readers who lack fluency are often still struggling with **decoding**. Their working memory is bogged down with **decoding** sounds and letters, so they can’t read quickly and accurately yet. Dysfluent reading also affects reading comprehension abilities. Since poorer readers cannot read with automaticity, they have difficulty building a picture in their minds of what the text is saying. However, it’s worth noting that reading quickly isn’t enough to establish fluency. A reader must be able to associate expression or prosody with the words to glean meaning from the text. This is why schools focus on reading with expression. **Here** are some tips from an experienced teacher on *How to Read Aloud with Your Child*.





The words readers must know in order to understand what they read.

Children become better readers when they can quickly connect the words they know already to the words they see in a text. This means that a strong oral vocabulary is critical to becoming a good reader. It also means that teaching children relevant words that they are going to encounter in school and in books is crucial.

To learn new vocabulary effectively, children need to encounter words within a relevant context. Context helps children better understand what each word means, how it relates to the world around them, and how it is used. Building context around a new word helps children better retain this word in memory.

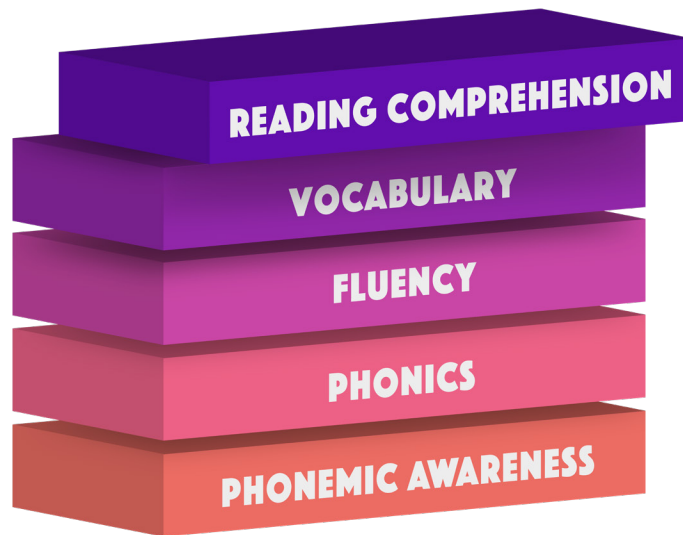
To comprehend the words we read, we must first know their meanings. For example, the word “ambulance” means nothing to someone who has never heard the word, seen the vehicle, or lacks prior exposure to relevant topics. Children become better readers when they can quickly connect their oral vocabularies to their reading vocabularies. This means that a strong oral vocabulary is critical to becoming a good reader. Literacy experts suggest that talking to children as often as possible when they are young supports their oral vocabulary growth and development. The importance of early oral vocabulary growth is why we say that oral literacy precedes written literacy.

Vocabulary development is closely correlated with reading comprehension and general academic achievement. Unless students know what the words they encounter when reading mean, they can neither enjoy the content of a text nor learn from it. This makes vocabulary vital for reading comprehension and learning in general. Research studies have reported that thorough vocabulary teaching was associated with improvement in reading comprehension.⁸

There are two primary ways of learning new vocabulary words. The first is **explicit vocabulary instruction**. This method, used in all Mrs Wordsmith products, involves the explicit teaching of vocabulary terms, pronunciations, and definitions. Children can learn vocabulary explicitly from teachers and parents or through resources like flashcards, apps, and dictionaries. The other critical method for learning vocabulary is implicitly through **context**. Context clues are the ‘hints’ contained in a text or spoken conversation that help a reader determine the meaning of an unfamiliar word. Children can also learn words using context clues to glean meaning from a text. Importantly, the role of context is crucial in both explicit and implicit vocabulary learning because it is what helps children understand how words relate to their surrounding world, what they mean, and how they are used. Context also helps children build associations between newly acquired words and existing background knowledge which helps them better retain these new words.⁹

See **Why Words Matter** for a research summary on why learning vocabulary matters to reading achievement and overall academic performance.





**The ability to understand the meaning of a text.
This relates to *why* we read — to enjoy stories
and learn new things.**

Reading comprehension draws upon all the other building blocks of reading, especially fluency and vocabulary, but also requires reasoning skills in order to draw links between what we read and our background knowledge.



The final building block of effective literacy instruction is reading comprehension. Reading comprehension is understanding the meaning of a text, and is ultimately the reason *why* we read — to enjoy stories and to learn new things.

Reading comprehension draws upon all the building blocks of reading, especially fluency and vocabulary. When we put words together with automaticity and use prior knowledge we derive meaning from a text. In this sense, reading comprehension not only relies on reading skills but also thinking and reasoning skills. When a reader is actively engaged with a text, they ask and answer questions about the story and are able to replay what they have read. Like vocabulary, reading comprehension skills develop and improve over time through instruction and practice.



READING ALOUD WITH YOUR CHILD IS BRAIN-CHANGING

Reading with your child is a “brain-changing” activity. Innumerable studies have shown that shared reading between an adult and a child has many important benefits for children.

Shared reading causes the activation and firing of neurons in the brain, creating new circuits and strengthening existing ones.

Studies have found that children who are exposed to strong home reading environments develop larger neural circuits that support narrative comprehension, a process that facilitates learning to read and write.¹⁰

Shared reading is so influential for children, that even modest increases in the activity are associated with improved brain function of the areas supporting literacy development. The more engaged a child is during shared reading, the better, faster, and stronger the connections between neurons become.¹¹

Children who are encouraged to engage reciprocally with an adult reader, in the form of questions and exchanging of opinions, also form stronger social-emotional connections between stories and their own life.

READING MAKES US FEEL HAPPY AND MORE CONNECTED

Cross-cultural data reveals that developing the habit of reading for pleasure is a bigger contributor to a child's educational success than a family's socio-economic status.¹² The idea is that the more someone enjoys reading, the more they will read and, as a result, the more they will learn. Scientific evidence also shows that reading for pleasure contributes to our happiness and wellbeing. Reading for pleasure is "oriented towards finding personal meaning and purpose and is related to the human need to make sense of the world, the desire to understand, to make things work, to make connections, engage emotionally and feel deeply."¹³

Reading also benefits the quality of our social relationships because high-quality fiction requires intellectual engagement and a huge amount of empathy.¹⁴ Identifying with a character and following them on a journey cultivates a reader's understanding and empathy toward that character. A deep understanding of complex emotional situations can then be transferred to the reader's own reality and social relationships.

The possibility of sharing the reading experience with others increases the pleasure of engaging with a narrative. Talking about books and topics that are relevant to their lives, with adults and peers, encourages children to really engage with texts and feel more comfortable making their voices heard.¹⁵



HOW GAMING CAN BENEFIT THE DEVELOPMENT OF LITERACY SKILLS

Kids learn best through play. High-quality games promote problem solving and independent learning. **Gameplay is particularly beneficial for vocabulary learning** because active engagement with words contributes to their retainment in memory.¹⁶ Since **children learn best by doing**, active learning is critical to effective learning.¹⁷

Research has shown that the gamification of learning is beneficial for the following reasons:

- 1 Games can be set up to provide constructive feedback as children learn, allowing them to try until they succeed.
- 2 Children feel accomplished when they manage to successfully overcome a challenge through play.
- 3 Gaming can be tailored to the player's skills, increasing the difficulty as their performance improves.
- 4 Gaming allows for realistic two-way interactions with users and characters that combine entertainment with education. On-screen characters can direct children's attention to important concepts or ideas.



HOW CHARACTER-BASED LEARNING CAN BENEFIT THE DEVELOPMENT OF LITERACY SKILLS

Research indicates that numerous educational and psychological benefits occur for children who create strong relationships with fictional characters.¹⁸

These benefits include:

- Better retention when ideas are presented by characters
- Better retention of new information if children are helping a character complete a mission
- Development of empathy when children identify with a character
- Feelings of warmth and comfort from relating to characters

When introducing children to educational games, the type of characters and context matter. Children are discerning and connect more to relatable characters. Certain features make characters relatable, such as having human-like qualities and needs, being realistic, or having predictable behavior. Interestingly, children absorb more information from intelligent characters.



In addition, playing a game with a diverse cast of characters can be beneficial to a child's learning, as children are more likely to find a character that they identify with if they have a broad set of personalities and experiences to choose from.

Relatable characters who advance a narrative using targeted educational content result in higher retention of those concepts by children.¹⁹ Children respond well to being asked to help a fictional character solve a problem, especially if they have already built a relationship with the character in question.

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