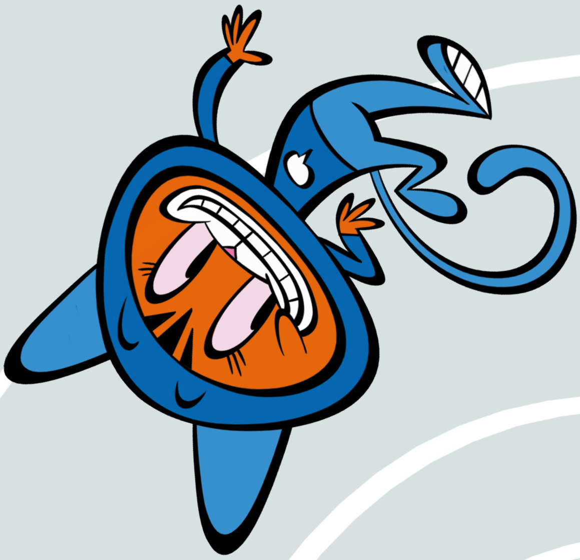
Mrs Wordsmith®



THE SCIENCE OF READING

INTRODUCTION

This report is an independent overview of the research on the science of reading. It looks at decades of academic research on the neuroscience of reading and on best practices of reading instruction, including findings which inform educational policy-makers in the US and UK.[1, 2] In doing so, it confirms the important connection between how the brain learns to read and how we teach children to read.

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, learning to read and write has to be explicitly taught. If this is not done properly, many children will struggle! A good reading instruction helps children to train their brain to connect spoken language circuits with learned image circuits -- in the case of reading, these images are the letters. The newly forged connections between letters and sounds create neural networks that enable us to read. What is critical is that children have repeated exposures to these new connections in order 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]

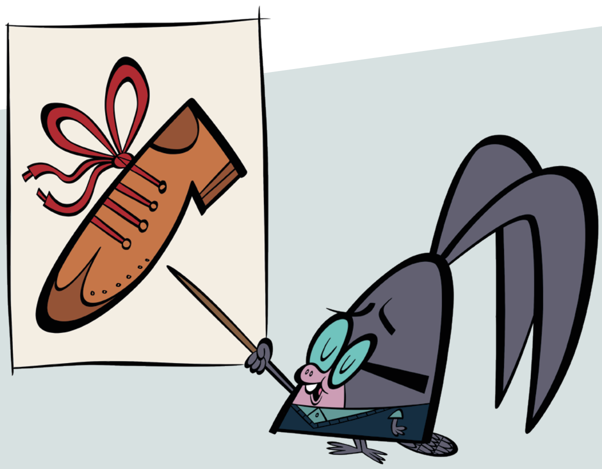
Broken down into individual steps, the process of reading involves:

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 struggle to learn how to perform 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.

A BRAIN BEFORE IT LEARNS TO READ

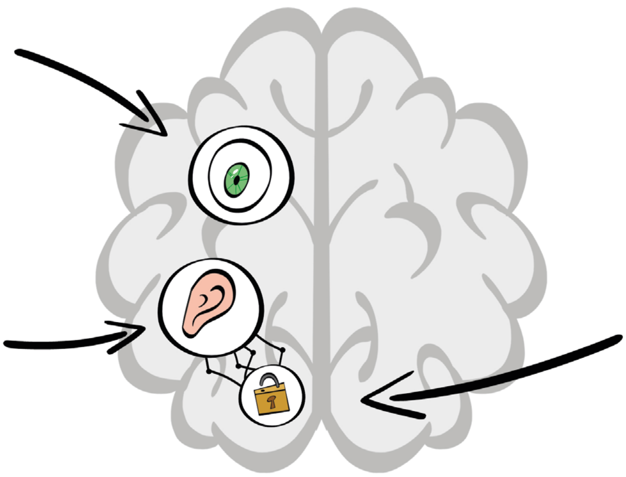
AGED 0–3

VISUAL CORTEX

The **visual cortex** is where the brain 'sees' things. It helps us see and identify objects, shapes, pictures, and people.

AUDITORY CORTEX

The **auditory cortex** is where the brain 'hears' things. It processes sounds.

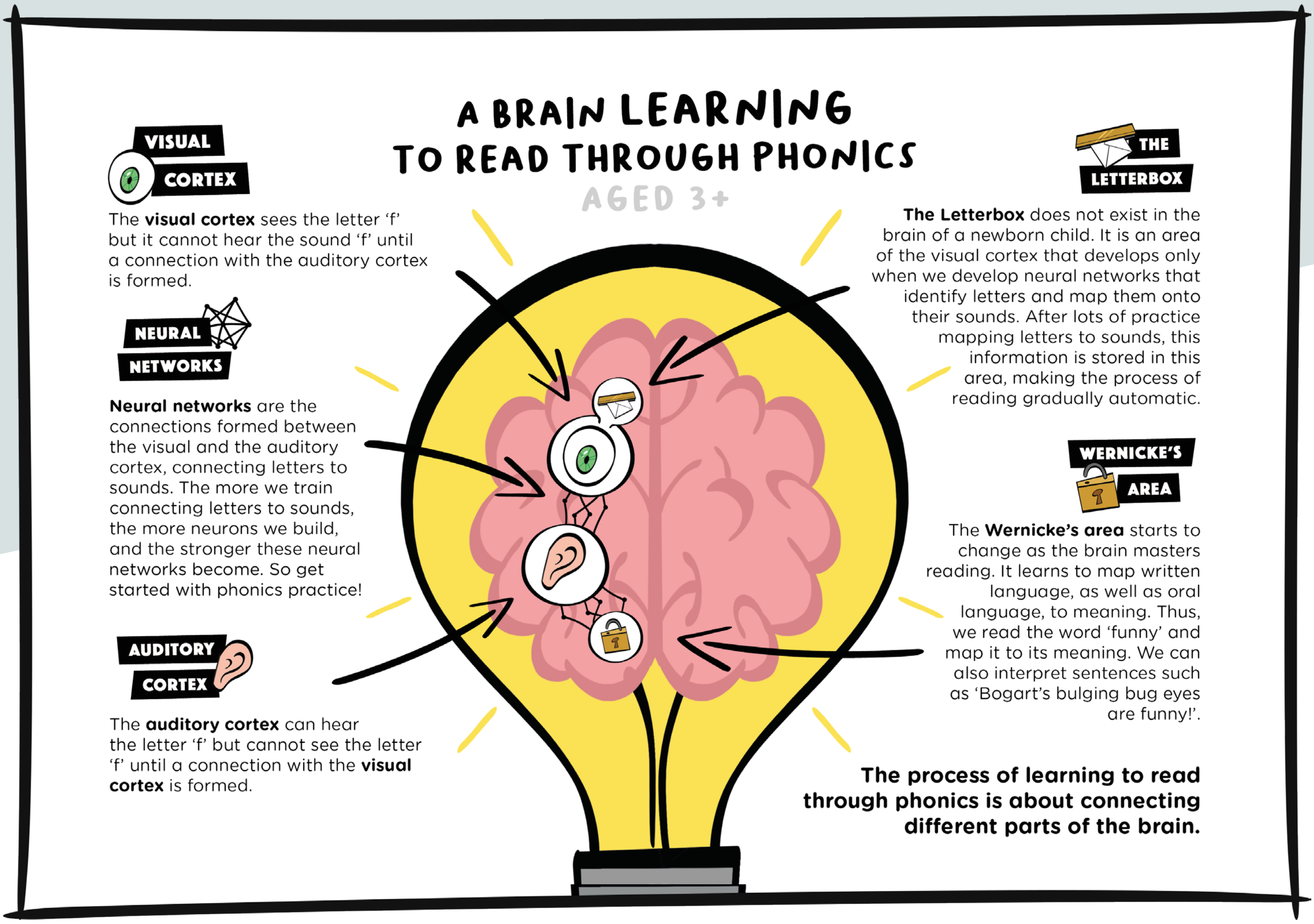


WERNICKE'S AREA

The **Wernicke's area** is where the brain understands what things 'mean'. It maps the words we hear to their meaning and helps us process sentences. Before we learn to read, the Wernicke's area helps us bring meaning to spoken language. This is why talking to children is important. Oral literacy comes before written literacy.

Before we learn to read, the parts of the brain related to connecting letters to sounds are disconnected.

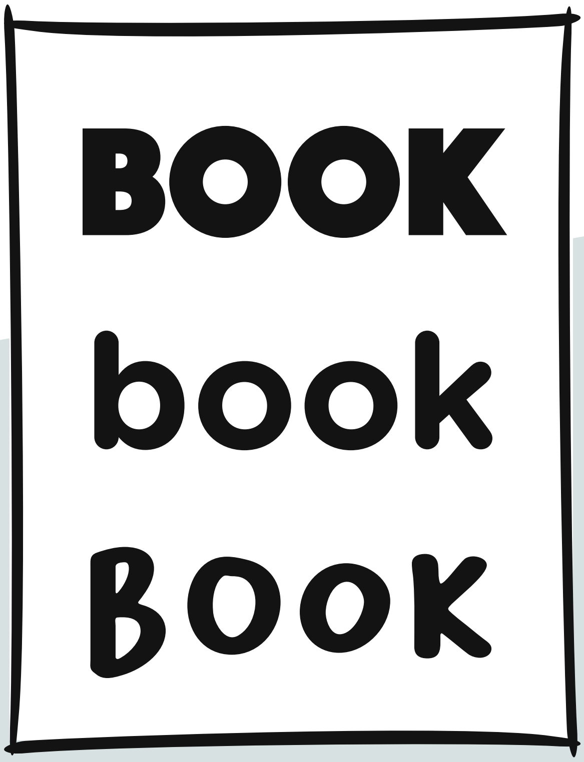
To read words, a child's brain needs to develop new neural networks that connect the visual cortex with the auditory cortex. It needs to connect the letter it 'sees' to the sound it 'hears'. For example, when the visual cortex sees the letter 'f' and the auditory cortex hears the sound 'f' as in 'funny', a new connection is formed. Repeated exposure to these letter-sound correspondences builds new connections between the visual cortex and the auditory cortex.



As shown in the diagram above, the ability to map letters to sounds develops new areas in the brain. That's why learning phonics helps build the neural networks required for fluent reading.

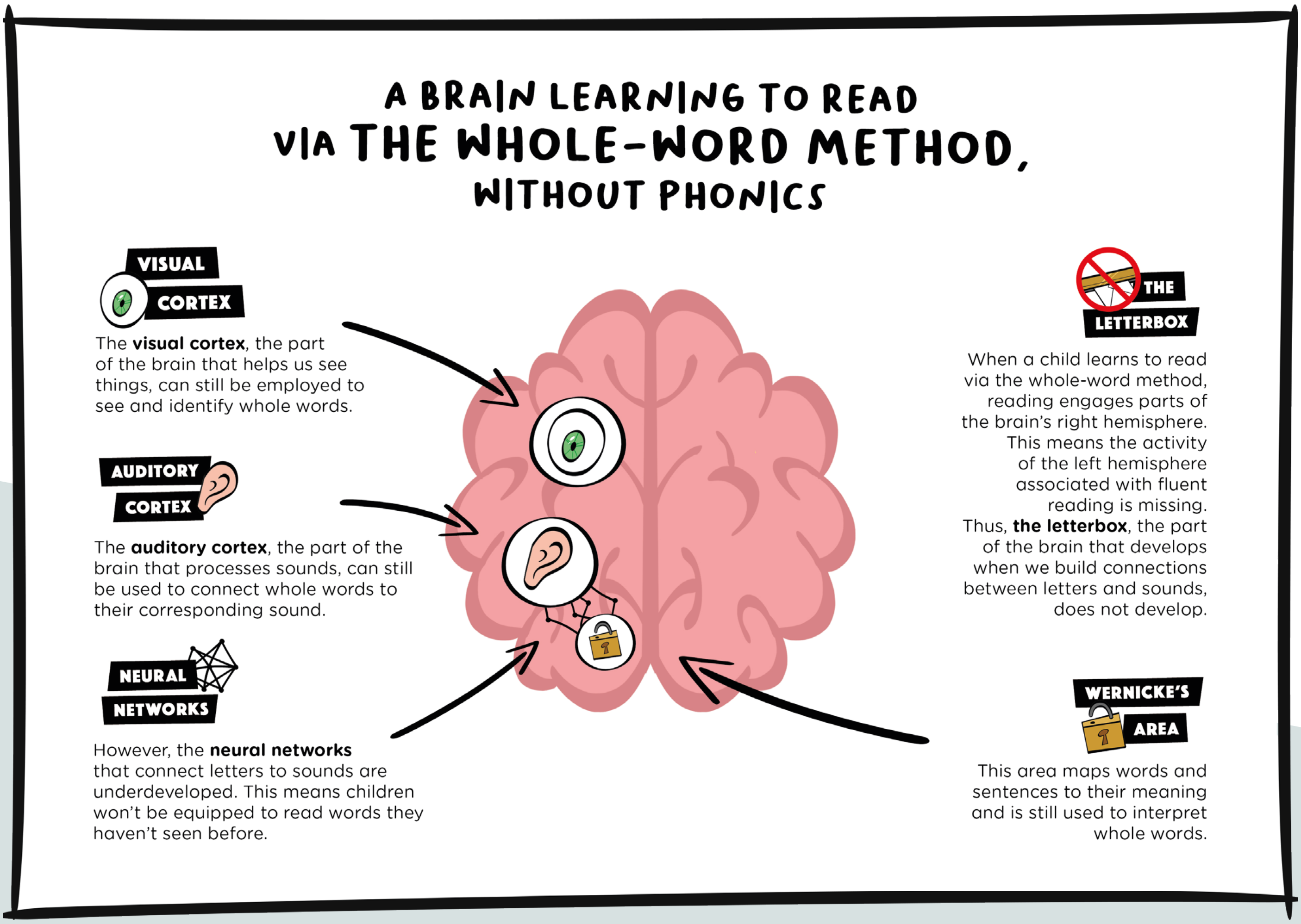
The process of decoding words or blending letters into whole words sends information to *the letterbox,* an area of the visual cortex dedicated to written words. This area only develops when we are beginning to read and does not exist in very young children or illiterate adults. Information about the 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.[5]

For a child learning to read, the process of mapping letters to sounds is slow and laborious. With time, this process becomes automatic. Learners need to encounter words again and again to start identifying them instantly, without having to decode them letter by letter. It is far more beneficial to learn to associate letters and sounds with phonics than to learn to read with 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.

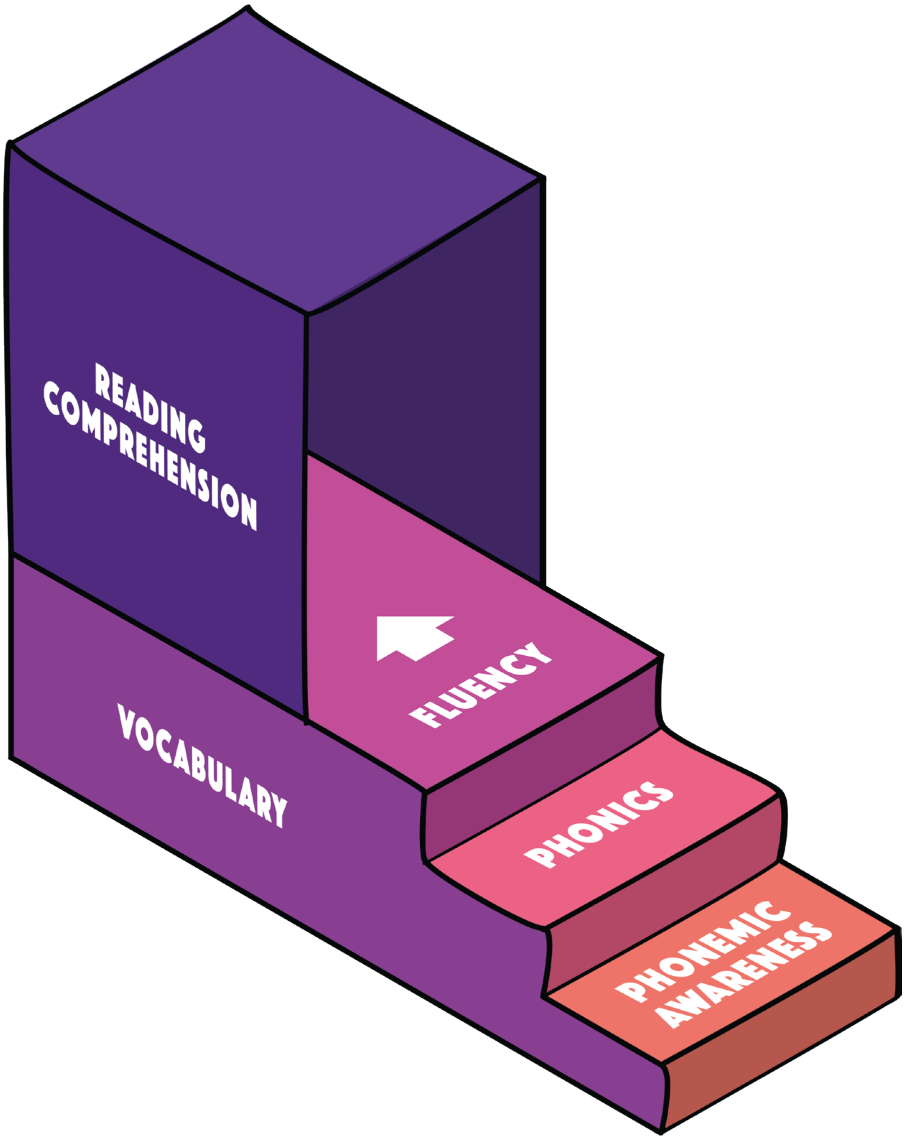
Studies have identified certain patterns of activity that occur in the left brain hemispheres of fluent readers. One study comparing the neural activity of a fluent reader to that of an individual learning to read found that learners using phonics showed high levels of activity in the brain's left hemisphere.[6] 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.



Phonics is one of the science-based building blocks of reading. It needs to be taught within a systematic scaffolded approach including the other building blocks of reading, as we will explain below.

THE FIVE BUILDING BLOCKS OF READING

Phonics is one of the five science-based building blocks of reading. According to the Science of Reading approach, the skills listed below build on each other and are all equally important in the gradual process of learning to read. They are thus referred to as "The building blocks of reading."



PHONEMIC AWARENESS

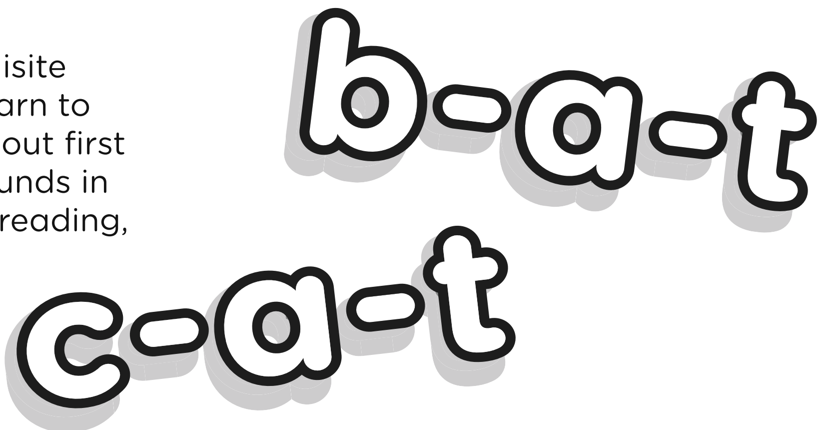
Phonemic awareness is the ability to identify and manipulate the individual sounds that make up spoken words. This is the first skill that children must master when learning how to read because it enables them to match sounds to letters later on. It is one of the most important factors in determining a child's future reading success.[7] 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 prerequisite 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 'cat,' they are more likely to quickly recognise the letters that correspond to the sounds in print. Phonemic awareness can be built through exercises that ask children to identify the first phoneme in a word, or to swap a sound with another one to make a new word, as in cat, hat, bat which differ only in their first phoneme. Another exercise that helps children build phonemic awareness is finding rhyming words, like, play, day, ray -- these words rhyme because they end with the same phoneme. Phonemic awareness 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). As children develop an awareness of the sounds that create spoken words, they also develop an awareness of the way words are constructed, which will help them not only in reading but also in spelling.



PHONICS

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 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. Children also learn the different ways in which a sound can be spelled. For example, *p**ai**nt*, *pl**ay***, and *m**a**k**e*** have the same vowel sound written using different graphemes.

Phonics instruction teaches children how to sound out words. 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.[8] For a more detailed account of phonics instruction, see **Phonics Deep Dive**.

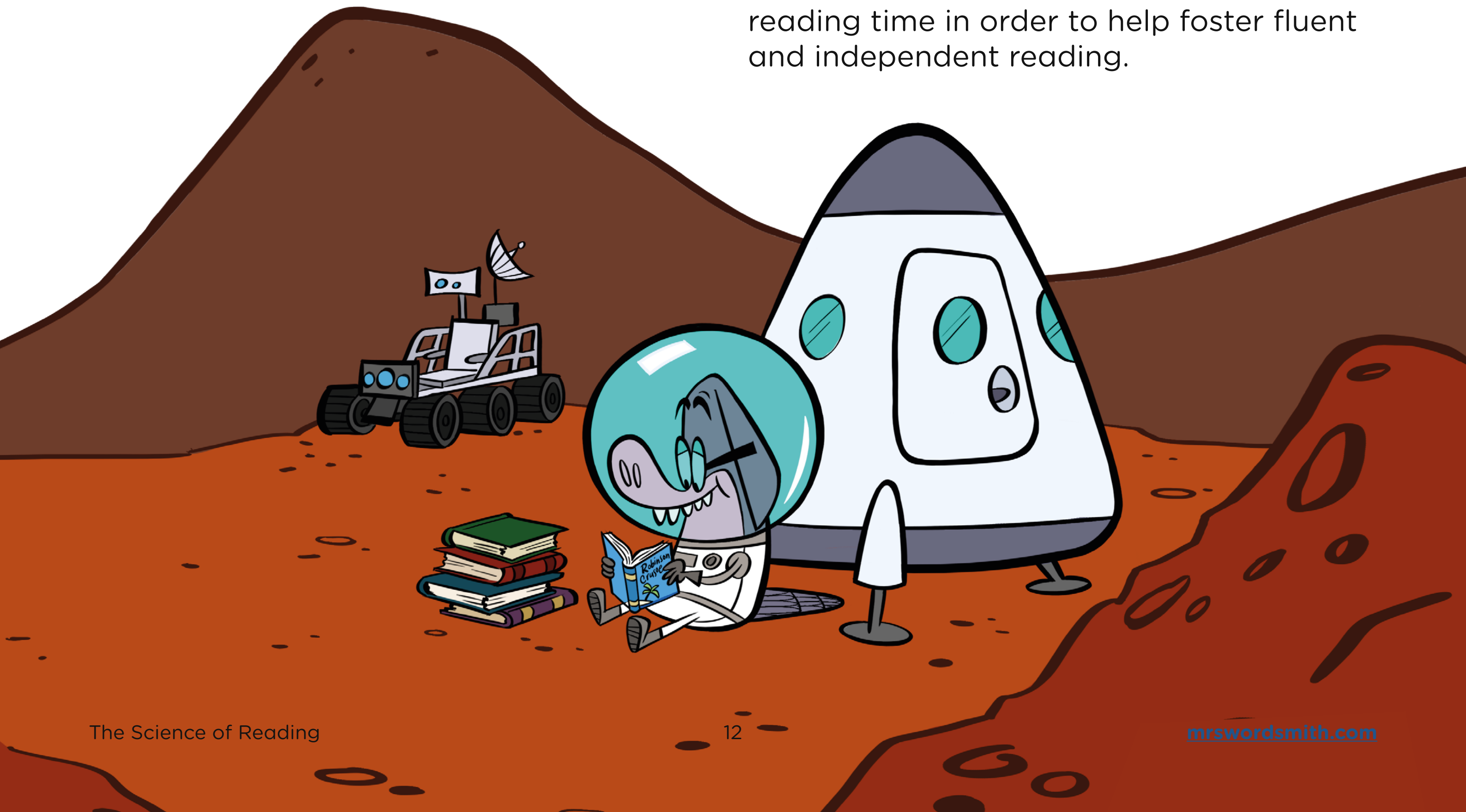
Phonics Deep Dive
https://cdn.shopify.com/s/files/1/1000/7604/files/Phonics_Deep_Dive_UK_AU.pdf?v=1607091544

FLUENCY

Reading fluency is the ability to read 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. Non-fluent 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. In other words, fluent reading should resemble spoken language, both in terms of pace and in terms of phrasing and expression. **Here are some tips from an experienced teacher** on how to make the most of reading time in order to help foster fluent and independent reading.



VOCABULARY

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. It is also the reason that vocabulary learning works throughout the other building blocks of reading: children learn words orally even before they master decoding, and they keep learning new words for the rest of their lives.

There is a strong positive association between vocabulary development on one hand and both reading comprehension and general academic achievement on the other. This is because a developed vocabulary helps us better understand what we read. When we better understand what we read, we acquire knowledge from it more easily. A substantial body of research evidence supports this, including these findings:

- Children with a richer vocabulary at the start of their education are likely to continue having this advantage throughout their lives. This is because having a larger vocabulary provides greater access to a range of oral and reading experiences that improve it even more. This is commonly referred to as "the Matthew effect" in vocabulary development.[9, 10] Readers need to know 95-98% of the words in a text to be able to comprehend it. This means that about five unknown words on a page are enough to block comprehension.[11] In other words, even though it is well known that reading is causally related to knowledge, unknown words can stand in the way of this.

- In order to achieve the 98% coverage required for comprehension, knowledge of 8,000 to 9,000 word families is required.[12]

- Many children who learn to decode successfully in grade one or two are still unable to comprehend the books they need to read by grade three or four due to the lack of adequate vocabulary.[13] In other words, even though systematic phonics instruction is crucial, learning to read alone is not enough – children need to be taught the meaning of the words they read.

- Unsurprisingly, thorough vocabulary instruction has been found to lead to an improvement in reading comprehension.[14]

There are two primary methods for learning new vocabulary. The first is explicit vocabulary instruction. This method involves the explicit teaching of words together with information around how they are pronounced, what they mean, and how they are used in context. Children can learn vocabulary explicitly from teachers and parents or through resources like educational games, apps, flashcards, and dictionaries.

The other method for learning vocabulary is implicitly through context. Context clues are the 'hints' contained in a written text or spoken conversation that help a reader determine the meaning of an unfamiliar word. However, not all contexts contain enough information for a child to derive the correct meaning of a new word. Some contexts are too general and some can even be misleading.[15] And even though encountering words in context is essential for a child to understand how a word is used, the appropriate type of context that gives enough information about what a word means (also known as 'directive context') is more likely to appear in materials constructed for explicit vocabulary instruction.

Indeed, even though both implicit and explicit vocabulary instruction can lead to vocabulary gains, converging evidence supports that explicit vocabulary instruction yields significantly better results. [16, 17, 18, 19]

Here is some research evidence in support of direct vocabulary instruction:

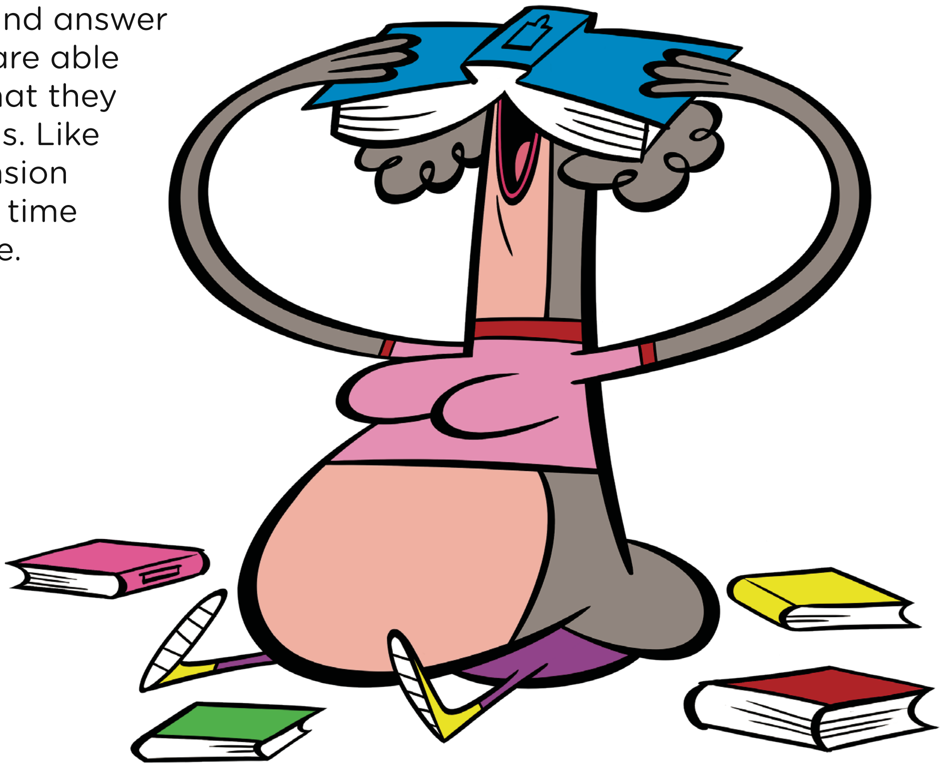
- Left to read alone, the average child will spontaneously "work out" the meanings of only 15% of the unfamiliar words they encounter.[20]

- Even if the meaning of an unknown word is worked out, this doesn't guarantee that the word will be stored in the long-term memory for retrieval later. For words to be remembered, children need about 8 exposures -- a number that could be even larger for struggling readers.[21] But just like directive contexts, systematic repetition (or spaced repetition) is more likely to occur in explicit vocabulary instruction.

READING COMPREHENSION

The ultimate goal of effective literacy instruction is reading comprehension. Reading comprehension is the ability to understand 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 read words with automaticity and map them onto their meaning because we already have access to it, we can easily derive meaning from a text. Of course, reading comprehension requires inference and background knowledge, so it also relies on reasoning skills, but unless decoding and vocabulary are mastered, the brain will not have enough capacity for complex reasoning. When a reader is actively engaged with a text, they ask and answer questions about the story and are able to describe the main idea of what they have read using their own words. Like vocabulary, reading comprehension skills develop and improve over time through instruction and practice.



CONCLUSION

Comprehension sets kids up for easier learning and communication in school and beyond and unlocks the enjoyment of reading and the acquisition of knowledge from it. But true comprehension is the culmination of successful reading training in the other four building blocks. Indeed, reading comprehension requires being able to decode words fluently (through phonemic awareness and phonics) as well as mapping them onto what they mean (through vocabulary instruction).

Reading is still relatively new to humanity. Our brains have the disparate resources to do it, but need external training to connect these resources. That's why a systematic approach following what we know from science about how the brain learns to read is the best way to ensure that kids' reading journey is a smooth one.

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