Lighting up young brains

How parents, carers and nurseries support children's brain development in the first five years

READ ON GET ON

Save the Children

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1 St John's Lane
London EC1M 4AR UK
+44 (0)20 7012 6400
savethechildren.org.uk

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Front cover: Joseph with his dad, David, at a play centre in London
(photo: Elena Heatherwick/Save the Children)

Foreword

Do you remember the first time someone opened a book and read a story to you, or when you were first encouraged to learn letter shapes or repeat their sounds? Probably not; yet without those events, my words and all printed text would be meaningless.

Talking, listening and reading become such automatic processes that it's easy to take them for granted, but all these skills must be learnt. Once acquired, they open the gateway to all accumulated human knowledge, providing a fundamental basis for education and independent learning.

Learning to talk, listen and read have strong impacts on the opportunities a child will later have to improve their own well-being – ie, their life chances. As highlighted in this excellent review, insights from fields as diverse as education, genetics and neuroscience are converging to make us more confident of this simple fact than ever before.

But these gifts must be passed from one generation to the next, and this happens through providing a child with experiences that carefully build their understanding. That is why it's so critical for those responsible for early childcare – both parents and those who work in our nurseries – to understand how a child develops, to be fully aware of their role in children's early learning and the implications of this learning for their future.

For these reasons, I am delighted that Save the Children is launching this campaign to raise awareness of the importance of children's early development. I greatly hope that in the near future, all nurseries will benefit from an early years teacher supporting children, staff and parents in ensuring the best possible start to a long story of learning.

Professor Paul Howard-Jones

University of Bristol

Executive summary

The science is clear. In the first few years of life, a child's brain develops rapidly, driven by a mix of experience, environment and genes. Children will continue to develop throughout childhood and into adulthood, but in the early years their brains are particularly sensitive. By contrast, the science shows that as a child grows older it becomes much more difficult to influence the way their brain processes information.

From birth to age two the brain goes through a period of rapid development and growth

During the first two years of life the brain displays a remarkable capacity to absorb information and adapt to its surroundings.

- A fully-grown adult brain has an estimated 86 billion neurons, the majority of which are already formed in the womb (Herculano-Houzel 2009, Goswami 2015).
- By age one, the size of a child's brain is already 72% of adult volume on average and by age two it has grown to 83% of an adult's volume on average (Knickmeyer et. al. 2008).
- At age two, the connections that are being formed in a child's brain are happening about twice as fast as in an adult's brain (Stiles & Jernigan 2010).

Between age three to five the brain starts to process information in more efficient and complex ways

From age three, a child's brain begins a phase called 'synaptic pruning'. This is a period in a child's life where the brain becomes more efficient and more complex through refining the networks that were formed during the first two years.

- At age three a child's brain is estimated to be about twice as active as an adult's brain (Brotherson 2009).
- At age five a child's brain uses almost twice as much energy as an adult's brain to support brain development (Kuzawa et al 2013)

This period from age three to five is also critical for children's language skills. A child's language skills develop rapidly during the first few years of life:

- On average, a child's vocabulary expands from 55 words at 16 months, to 225 words at 23 months to 573 words at 30 months (Goswami 2015)

We now know that the relationship between young children's brain development and the emergence of language skills is mutually reinforcing (Rosselli et al 2014). Each of these new words that a child learns helps to strengthen the architecture of the brain. And as that architecture is strengthened, children's capacity to recognise and use new words grows.

Throughout these first five years parents, carers and childcare workers provide crucial support to a growing child

The evidence presented in this paper shows that it's not only a child's genes that determine his or her brain and language development during this period. The experiences and environments that support this interactive process of early language and brain development are also critical:

- **Parents and carers have the biggest influence on their child's early learning:** A strong relationship with a parent or carer gives a young child the confidence to explore the world, while everyday activities like talking and sharing books help stimulate young children's language skills right from birth.

- **Childcare is playing an increasingly significant role in children's development:** More and more young children are spending at least part of their day at nursery. Good-quality childcare has been shown to have long-standing benefits for children's language development and educational outcomes.

The government needs to do much more to invest in good-quality childcare to support every child's development

Last year six children in every reception class in England struggled with their early language skills. That's the equivalent of every five year old in reception class in London, Manchester, Sheffield, Liverpool and Newcastle.

We need to do much more to ensure that every child gets the best support in the early years. That's why we're calling on the government to invest in good quality childcare to support children's early development.

While we welcome the government's focus on expanding access to free childcare, we want the government, working closely with nurseries, to do more to ensure that every child has access to high-quality childcare. This will help ensure that every child, especially those living in poverty, benefits from the best early learning opportunities in these critical years.

That's why we're calling on the government to ensure that there is an early years teacher in every nursery in England by 2020.

The Read On. Get On. campaign

Save the Children is part of the Read On. Get On. campaign – a coalition of literacy experts, early years professionals, teachers and businesses working towards the ambitious goal of all children reading well by the age of 11 by 2025.

In England, one in five children cannot read well when they finish primary school, a figure that increases to one in three of the poorest children. Children who cannot read well at the end of primary school are less likely to succeed in secondary school (Read On. Get On. 2014).

To become good readers, children first need to become confident communicators, with clear speech, a rapidly increasing vocabulary and strong levels of comprehension. These vital language skills develop rapidly in the first few years of a child's life.

That's why the Read On. Get On. campaign is also working to ensure that every five-year-old has good language skills by 2020.

1 Children's early brain development

From saying their first word to learning to walk, the first few years of any child's life are marked by rapid changes. This section highlights some of the recent evidence from neuroscience on the development of the brain in the first five years. This is a sensitive period in a child's life that sets the foundations for their later life. While every child will go on to learn and develop throughout their lives, it becomes more difficult as they grow older to influence the way their brain processes information.

From birth to age two the brain develops at a remarkable pace

In the first two years of life, a child starts to develop a wide range of skills and abilities. During this time a child will start to explore and learn about the world around them through developing communication skills, behaviours and emotional attachments. New evidence from neuroscience shows how these changes are reflected in a child's brain development.

A child's brain begins developing in the womb. A fully-grown adult brain has an estimated 86 billion neurons – the information processing cells in the brain. But the majority of them are actually formed in the womb (Herculano-Houzel 2009, Goswami 2015). Then, during infancy, the connections between neurons become stronger and more extensive, with new connections forming. These connections form the networks that underlie children's development (Stiles & Jernigan 2010). However, when a child is born these networks are not as robustly connected.

Networks are not just made up of neurons. Axons and dendrites are the wires that connect neurons together. Neurons send out-going messages along their axons, and receive incoming information through their dendrites (Stiles & Jernigan 2010). Myelination – when axons are coated in myelin, a fatty-substance which insulates and protects neurons – is an important process that occurs as networks develop. This insulation helps to increase the speed at which information can flow along an axon. And it allows children to rapidly process information from the world around them. Some circuits in the brain become myelinated earlier than others. For language circuits, the process of myelination is prolonged, continuing throughout childhood and into adulthood (Paus et al., 1999).

At the point of connection between axons and dendrites, synapses are formed. Synapses allow messages to be passed from the axon of one neuron, to the dendrite of another neuron. At age two these connections are being formed about twice as fast as in an adult's brain (Stiles & Jernigan 2010). A staggering 700 new connections are formed every second on average (National Scientific Council on the Developing Child 2007). With the connection of synapses come many of a child's developmental milestones, such as the development of memory. At this stage in development, the brain is over-connected compared with an adult's brain.

Throughout the first two years, a child's brain is also growing rapidly in size. During the first year of life, the size of a child's brain increases by 101% on average. During the second year this pace slows, but still increases by 15% on average. By age one, the size of a child's brain is already 72% of adult volume on average; by age two it has grown to 83% of an adult's brain size on average (Knickmeyer et. al. 2008).

How are we learning about early brain development?

Studies from neuroscience are giving us an ever more detailed understanding of the development of the brain. To do this, neuroscientists use a wide range of advanced techniques.

Functional magnetic resonance imaging (fMRI) is a brain imaging technique that provides researchers with a window into the living brain. Using magnets, fMRI measures changes in the ratio of oxygenated and de-oxygenated blood throughout the brain while a task is being performed. Areas

of the brain that are involved in performing the task show more de-oxygenated blood because they have consumed lots of energy (and therefore oxygen).

Electroencephalography (EEG) is a really important tool for researchers to understand how the brain develops very early in life as it can be used for babies (as well as older children). It's made up of a net of electrodes worn on the head (see picture), which detect electrical signals from the brain. These signals fluctuate over time, creating brain waves. By comparing the shape and timings of the waves, researchers can begin to understand how the brain processes information from the outside world and how this changes during development.

Diffusion tensor imaging (DTI) is a method used to acquire a special type of brain image on an MRI scanner. DTI measures the diffusion of water molecules in the brain. Water molecules inside brain connections travel in a particular direction, along that connection. In contrast, water molecules outside the connections (around the neurons) move around randomly. This is similar to water molecules in a straw that is standing in a glass of water: inside the straw, water molecules move up or down the straw; but outside the straw they diffuse in all directions. By looking at these different patterns of diffusion of water molecules in the brain, researchers can detect areas of the brain where water travels in a strong direction, identifying the pathways of the brain.

Tractography is a special mathematical technique that can be applied to diffusion tensor images to trace very specific pathways in the brain. It does this by predicting the most likely direction of travel for the water molecules within brain connections, separating out pathways that lie close together but travel in different directions. Even more excitingly, tractography colour codes the images to indicate whether the flow of information along a pathway goes forward and backwards in the brain, side to side, or up and down.

As a child grows the brain goes through a process of refinement that improves efficiency and complexity

By age three, a child's social, cognitive and behavioural skills are developing rapidly. From having only been able to use simple words and short sentences in the first two years, a child's language develops quickly, learning two or three words a day on average, and starting to use words in increasingly complex ways. They will also start to walk and run, develop friendships, begin to experiment with objects, and act more independently of their parents and carers.

By age three, a child's brain is estimated to be twice as active as an adult's brain (Brotherson 2009). At the same time, the rapid growth in the size of a child's brain and in the formation of synapses begin to slow (Knickmeyer et. al. 2008, Goswami 2015).

At about this stage, the child's over-connected brain starts to undergo a fine-tuning process known by experts as 'synaptic pruning'. This process lasts well beyond the first five years. During this time neural connections are refined to reflect the particular environment the child is living in, enhancing the efficiency and strength of the most important brain networks (Tau & Peterson 2010).

Connections that are least relevant to the child's environment are lost, while those that are important grow more efficient and complex. For example, the parts of a child's brain that focus on sound become more and more complex, and more attuned to the particular language (or languages) that a child has been exposed to in the early years. As they grow a child becomes more and more proficient in using this language (National Scientific Council on the Developing Child 2007). Without these early environments and experiences a child may struggle to grow their language skills in the same way as their peers.

Throughout this period, myelination also continues. From birth, myelination begins in regions that control primary senses, such as the use of ears and eyes, and motor control, such as reaching and

grabbing. As children, grow myelination progresses to regions that control more complex processes, such as perception, thoughts, memories, and feelings (Dubois et al., 2008).

Some experts have described this process as the brain 'growing from the bottom up'. For example, a child first starts to develop their sensory pathways (ie, their vision and ability to hear) in the womb. Subsequently, their language pathways begin to develop as they hear words used around them after birth. As they develop their language skills, children begin to develop more complex cognitive skills such as reasoning and comprehension (National Scientific Council on the Developing Child 2007).

Of course, a child will retain the ability to develop these different skills throughout childhood and into adulthood. But the science shows that as time goes on, brain circuits become increasingly difficult to change (National Scientific Council on the Developing Child 2007). It's the early experiences in life that lay the foundations for later development.

That's why the early years are such a critical time in a child's development. It's vital during this period that every child gets the best support. Parents, carers, nursery staff and others all play a crucial role during this. It's through their support that children can get the best start in life.

Good language development and brain development are interlinked and mutually reinforcing

Evidence from neuroscience is showing how early language skills are interrelated with children's brain development. Research is showing that this is a two-way relationship where good language development supports brain development and brain development supports the development of good language skills.

Good early language development has been shown to be closely related to changes in the development of the brain (Rosselli et al 2014). Language skills help children to develop a range of cognitive skills that are crucial for their development, including working memory and reading skills.

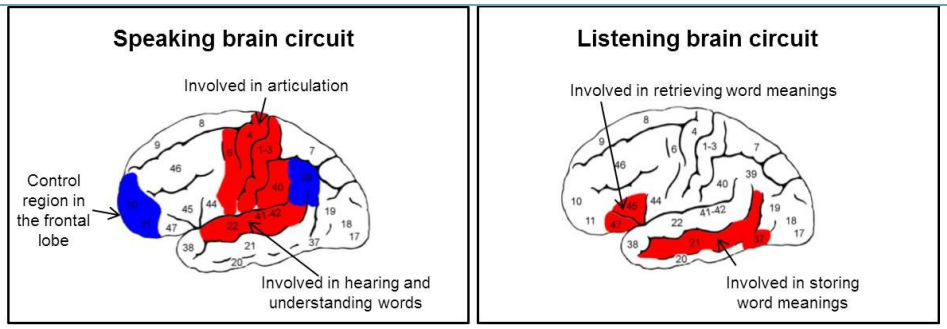
Healthy brain development is also crucial to children's early language skills. As a child's brain develops more complex and sophisticated processes, it supports the development of children's language skills. From using simple words to putting together complex sentences with correct grammar, the development of good language skills are dependent on the development of the brain (Rosselli et al 2014).

The Read On. Get On. campaign is working to ensure that every child has reached a good level of language development by age five in 2020. Today, more than 129,000 children are starting school without the language skills they need. Achieving our goal will be a challenge, but it's crucial if we're going to support all children in England to reach their potential.

Case study: How do language circuits in the brain change during childhood?

Researchers at the UCL Institute of Child Health wanted to understand know how activity in the neural circuit supporting language changes from 5–18 years of age, as language skills develop. The study involved reviewing all the fMRI studies of language development that had been published since the first reports of fMRI in humans (in 1992) to find the most consistent and reliable findings.

All 39 studies showed that development of the language circuit involves both increases and decreases in activation with age.



This means that as a child grows up, some parts of the brain become more involved in language, whereas others become less involved. Crucially, changes in activation varied for different aspects of language, such as speaking and listening.

Studies of speaking showed that parts of the brain involved in movement and hearing become increasingly active with age. At the same time activation reduces in 'control' areas of the brain.

It seems that as a child grows up, the parts of the brain involved in paying close attention to what they or others are saying become less and less involved. The parts of the brain involved in the more basic or 'lower level' functions, such as articulating and hearing, show the opposite, and seem to be more and more involved as a child grows up. This could mean that these changes are associated with speech becoming more automatic as children get older, with less reliance on highly controlled (energy-consuming) processes.

In contrast, studies of listening showed that parts of the brain involved in storing the meaning of words become more activated and more extensive with age. This could reflect the child's growing vocabulary in the brain.

The research was carried out by Dr Louise Weiss-Croft and Professor Torsten Baldeweg and published in NeuroImage, Vol. 123, December 2015 pgs. 269-281.

2 The role of parents and carers, the home learning environment and childcare in supporting a child's brain development

The evidence shows that a child's environment and experiences in the first few years of life play a crucial role in their brain development. This section focuses on three of the most important influences – a child's parents and carers, the home learning environment and childcare settings.

Parents and carers are the most crucial influence on children's development

Children experience the world through their relationships. These relationships affect virtually all aspects of their development (National Scientific Council on the Developing Child 2008). A child's central relationship is with their parent or parents and carers; as a result, parents and carers have a very strong influence on a child's brain development (APPG 2013).

Child–caregiver interactions, such as shared eye-contact, are especially important for getting word-learning off the ground in the first year of life. By following a parent's gaze to a named object, babies begin to learn that certain sounds and objects go together. It is through this association of sounds with objects, or sounds with actions, that infants are able to learn their first words (Morales et al., 1998).

Researchers describe the strength of this relationship as based on a continual 'give and take' between a child and their parent or carer. This means that when young children reach out for interaction, an adult who responds to the child helps to build and strengthen the child's brain development. They do this through creating a relationship where a child's experiences are affirmed, nurtured and supported (National Scientific Council on the Developing Child 2008).

Critically, the evidence also shows that growing up with an insecure relationship can affect a child's later physical and mental health, behaviour and education (APPG 2015).

Recent research suggests that this happens because a child's relationship with parents or carers plays a role in regulating their stress hormones. Children who have more secure relationships have more controlled stress hormone reactions. Children who have less secure relationships have higher stress hormone levels. This creates elevated hormone levels that can potentially alter the development of brain circuits in ways that make children less capable of coping with stress as they grow up (National Scientific Council on the Developing Child 2008).

Gemma on the first words of her daughter, Daisy, age two

"I'd like to say her first word was 'mummy', but I don't think it was. I think it was quite an obscure word, it might have been 'juice'.

"She's incredibly chatty, she talks all the time… it's a confidence issue though: she'll talk to me lots but she can be wary of speaking to other adults, so coming here [to the children's centre] is really good for getting her used to other people. The workers here try to have conversations with her, and encourage her to open up and relax, and talk to more people other than myself or her immediate family.

"I think it's absolutely key they develop an interest in books from a young age. As adults we know that if we're not interested in something we're not going to be overly keen on learning about it or learning how to do it. So if they have a strong basis, and they learn about the enjoyment from

reading and the imagination they can use and the facts that they can learn, then they will take that with them for the rest of their lives."

The home learning environment plays a critical role in children's development

It's not just the direct relationship between a parent or carer and a child that supports a child's development. It's also the role that parents play in creating a supportive environment for learning at home.

There's no straightforward recipe for what a good-quality home-learning environment looks like. However, research shows that it should provide both the kinds of experiences and the environment that a child needs for the development of their brains and their language skills. This could include plenty of books, and opportunities to be read to and to read, to learn rhymes and to sing songs. Studies have shown that these early activities continue to show positive benefits for children's education throughout their lives (Sylva et al 2004).

A high-quality environment for learning at home can have a huge impact on children's early learning (Sammons et al 2008, Speight et al. 2015). Research has shown that children's experiences of the home-learning environment from just 14 months old have a measurable impact on their language development at age three. Critically, it also shows that each aspect of the home-learning environment makes a unique contribution. This means that as a child grows, different activities reinforce each other over time (Rodriguez et al 2009).

Although starting as early as possible is important, studies also show that changes to the home environment can have an impact on children's early learning, even if introduced after the first year or two (Son and Morrison 2010).

TOP TIPS FOR PARENTS

You can help build your child's brain by talking to them right from the start.

For babies, play 'baby' games together (peepo or sticking your tongue out). Watch for your baby's reaction, and if they enjoy it, do it again:

- Respond to the noises your baby makes. Echo their cooing noises. Comment on what you think they might be trying to say – eg, "You like that, don't you?"

- Sing songs and look at pictures or books together. Your baby doesn't have to know what the words mean, they will enjoy spending time with you and hearing you talk or sing.

For toddlers, talk about what you see and hear around you:

- Keep your sentences short and simple. Use sentences that are one word longer than your toddler uses. So, if they say mainly one word sentences, you use two. This helps their understanding and teaches them what to aim for next.

- Keep dummies for bedtime – children who have a dummy in their mouth for a lot of the day don't get as much practice at talking. That can mean the sounds they use aren't clear and they may use fewer words.

For pre-school children, listen to what your child is trying to tell you and respond to them. Talk with your child about what's happening day-to-day:

- Your child can join in with daily tasks and you can talk together about what you are doing – eg, "I have to hang the washing up now," or "Can you find a sock?" Talking together helps build your child's brain and supports their early language development.

- Give your child plenty of time to respond when you are talking with them. Young children take time to understand what you have said and to plan what they want to say. Wait for them and then you can have a conversation together.

For more information and resources visit I CAN's www.talkingpoint.org.uk

High-quality nursery settings can play a crucial role in supporting a child's brain and language development

Alongside the support their parents or carers provide, childcare providers can also have a crucial impact on children's development.

Today more than 1.3 million three- and four-year-olds use the free entitlement of 15 hours of early education and care per week. On average, children spend about 17 hours per week in a formal setting (Huskinson et al 2014). With the introduction of 15 extra hours of free childcare for eligible parents, it's likely that many children will be spending even more time in childcare settings.

This is why it's so critical that every child has access to a high-quality childcare setting. We know that high-quality childcare can have a positive impact on a child's development (Sylva et al. 2004) and that early years teachers play a critical role in creating a high-quality learning environment (Mathers et al 2011). But many children are attending childcare settings who do not have access to an early years teacher (or staff with an equivalent degree-level qualification).

In particular, children are much less likely to attend a setting with an early years teacher if they are attending a private, voluntary or independent setting (PVI). Of particular concern is the finding that children growing up in disadvantaged areas are least likely to attend PVI settings with an early years teacher (Gambaro et al. 2013). This is crucial because the evidence shows that high-quality childcare has particular benefits for children from disadvantaged areas (Sylva et al 2004).

What a communication-friendly nursery looks like

In a communication-friendly nursery there are lots of activities and games planned that encourage children to talk, play and listen. Staff support children's language development in a range of ways – you might see them:

- talking carefully, using short sentences
- using simple language that children understand, just slightly longer than the child's
- getting down to the child's eye level when they talk to them
- often repeating the same things they say in everyday activities
- waiting after they've said something – giving children time to think
- using lots of pictures, gestures and things to look at when they talk
- commenting on what children are doing, and not asking too many questions.

Staff are also trained about typical early language development, so they know how important language is for learning, behaviour and social development. They can spot children who are having difficulty developing language – they will talk about this with parents and put in place extra support, and they work closely with specialists like speech and language therapists.

For more information on communication friendly settings visit I CAN's
http://www.talkingpoint.org.uk/ey-workers/adapting-environment

3 Our priority for government

In 2015, six children in every reception class in England struggled with their early language skills.[1] That's the equivalent of every five-year-old in reception class in London, Manchester, Sheffield, Liverpool and Newcastle.[2]

If we're going to ensure that every child gets the best start in life we need to do much more to make sure they have the best support in the early years.

A child's environment and experiences play a crucial role in their early learning – influencing both the development of their brain and their early language skills, which in turn can have a critical impact on how well they get on at school (APPG 2013).

It's critical that children, and particularly those growing up in poverty, have access to the highest-quality early learning experiences to support their development at home. Save the Children, as part of the *Read On. Get On.* coalition, is working with partners to strengthen existing support – and where necessary, to identify new approaches – to ensure that all parents have the capacity to provide the best early learning opportunities for their young child.

It's also crucial that every child has access to the highest-quality childcare settings to support their early development, particularly children who grow up in poverty and who will benefit the most from good-quality childcare. We know that early years teachers play a critical role in this and that is why our priority for government is:

For every nursery in England to be led by an early years teacher by 2020

[1] In 2015, 20% of children didn't reach the expected standard in language and communication. The average reception class size is 30 pupils, meaning that about 6 out of every 30 were not reaching the expected standard.
[2] In 2015, 129,573 children didn't reach the expected standard in language and communication. The total number of children attending reception in London, Manchester, Sheffield, Liverpool and Newcastle was 128,901.

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