



EARLY
INTERVENTION
FOUNDATION

SUMMARY

Key competencies in early cognitive development

Things, people, numbers and words

December 2018

**Kirsten Asmussen, James Law, Jenna Charlton, Daniel Acquah,
Lucy Brims, Inês Pote, Tom McBride**

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Public Health
England

Early Intervention Foundation

10 Salamanca Place
London SE1 7HB

W: www.EIF.org.uk
E: info@eif.org.uk
T: [@TheEIFoundation](https://twitter.com/TheEIFoundation)
P: +44 (0)20 3542 2481

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SUMMARY

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Summary

Aims and objectives

The Early Intervention Foundation (EIF) champions and supports the use of effective early intervention to improve the lives of children and young people at risk of experiencing poor outcomes. Two recent EIF reviews, *Foundations for Life* and *Language as a child wellbeing indicator*, have both identified early language development as a competency critically associated with children's overall wellbeing. This review expands upon these previous publications by summarising further evidence highlighting the importance of children's early language development, as well as three other competencies associated with their future success: children's understanding of objects, people and numbers. These four competencies were chosen because they draw from perceptual capabilities that are already present at birth and are viewed by many to represent the building blocks for children's later learning.¹

We provide this information with the ultimate aim of improving the effectiveness of early years services and reducing pervasive learning gaps associated with family income. In doing so, we:

- Provide a comprehensive summary of the most recent evidence involving the development of children's knowledge of objects, people, numbers and language. We intend this information to be used by early years providers and practitioners to strengthen current programmes and practices, as well as develop new ones.
- Identify factors which support the development of early competencies or place them at risk. We believe this knowledge will be particularly useful to commissioners of early years services, so that effective early interventions can be made available to children who need them the most.
- Translate the implications of this evidence for improving the quality of early years services, particularly those aimed at reducing income-related differences in children's cognitive performance at school. We believe this information is particularly useful for the development of policies aimed at increasing social mobility, as well as supporting children's cognitive development more generally.

Methodology

This review provides a comprehensive summary of the development of four important competencies during the first five years of life by systematically answering the following seven questions:

1. What is the competency?
2. In what ways is the competency supported by other child competencies?
3. How does the competency impact children's development over time?
4. What is typical development during the periods of infancy, toddlerhood and preschool?

¹ Spelke, E. S. (2017). Core knowledge, language, and number. *Language Learning and Development*, 13(2), 147–170.

5. Which factors support or hinder typical competency development?
6. What methods are most appropriate to assess typical and atypical development?
7. What are the implications for early intervention?

Hand search methods involving indexed journals were used to identify the most recent research on early cognitive development to answer questions 1–4. Systematic methods were used to identify large-scale cohort studies to answer question 5 (as described in appendix A). Findings from this second exercise were then augmented with relevant, smaller-scale studies identified through the hand search methods used for questions 1–4. The assessment tools identified for question 6 were obtained by collating information described in previous EIF reports and consultation with experts in the field. We answer question 7 by summarising the information reviewed in questions 1–6 in terms of its implications for early intervention commissioning and practice.

Principles underpinning early cognitive development

This review begins with an overview of many of the principles and assumptions that underpin the evidence we describe:

- Cognitive development is *never* the result of only nature or nurture. Cognitive development is the result of interdependent processes involving the child’s genetic make-up, age and environment.
- Children are born with a set of competencies which facilitate their early learning, but learning is also shaped by the family, community, culture and society.
- Children play an active role in their own cognitive development, informed by their current level of cognitive understanding.
- There is an age-related progression in children’s thought processes, whereby early capabilities lay the foundation for later capabilities.
- Cognitive development involves both general and specific processes.
- Cognitive capabilities are typically stable within individuals. Cognitive capabilities at earlier points of development are predictive of capabilities at later points, and the strength of these associations increase over time.
- Cognitive development is nevertheless malleable. Stable individual trajectories can and do change when the child’s circumstances change. Changes in circumstances can include the availability of effective interventions.

Findings: Children’s understanding of things

What is it?

Children’s knowledge of objects involves their understanding of the physical properties of objects, object categories and the relationship between objects and their ability to use objects as tools.

What other competencies are associated with children’s object knowledge?

- Children’s knowledge of objects is supported by their memory and other perceptual capabilities, the executive functions (for example, their working memory, attention inhibition, cognitive flexibility and information processing speed) and language development.

- Children’s knowledge of objects is also supported by their ability to share attention with and gain information from others. Studies show that joint attention activities are particularly associated with the learning of object names and the functionality of objects.
- Children’s object knowledge is also supported by their motor capabilities. Studies show that gross motor skills involving the ability to sit up and crawl can accelerate children’s interaction with objects, as do small motor skills which allow children to explore objects in terms of their critical features.

How does children’s knowledge of objects impact their cognitive development over time?

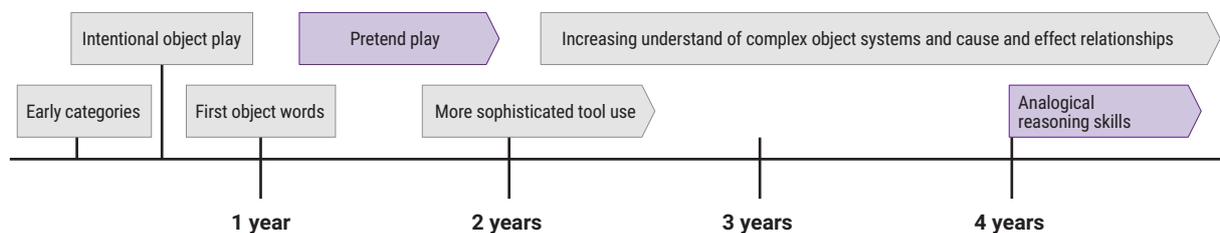
Children’s knowledge of objects and object relationships is identified as a core component of children’s intelligence, as measured by various scales (such as picture similarities) on IQ tests. Studies show that the manipulation of objects in infancy and knowledge of object relationships in preschool play a critical role in the development of problem-solving skills as children grow older. Studies show that children’s object knowledge in preschool is predictive of their intelligence test scores in primary school and academic performance in secondary school.

How do children’s theories of objects develop during the first five years?

Figure S1 provides an overview of the key milestones in children’s object knowledge occurring during the first five years.

FIGURE S1

Milestones in the development of children’s object knowledge during the first five years



Source: EIF

- Antenatal brain development is supported by proper maternal nutrition, reductions in stress, avoidance of harmful substances such as alcohol and tobacco and a full-term birth.
- In infancy, children’s object knowledge includes the ability to form object categories on the basis of their critical features, the intentional motor manipulation and exploration of objects and the rudimentary use of objects as tools (for example, using a blanket to pull an object closer).
- During the second year, many of children’s first words involve objects familiar to them on a daily basis. Other milestones occurring during the second year include the ability to engage in pretend play and increasingly sophisticated object categories and tool use.
- During the third, fourth and fifth years, children come to understand increasingly complex object relationships and systems. This knowledge, in turn, supports the development of children’s higher cognitive reasoning skills which are associated with their academic success during primary and secondary school.

What factors are associated with the development of children’s understanding of objects during the first five years?

Factors found to support children’s understanding of objects include:

- having a mother who gave birth to her first child between the ages of 30 and 39
- breastfeeding
- being read to
- family rules and routines
- learning opportunities outside of the home, including visits to parks, museums and other places of interests
- higher parental qualifications
- increased family income
- participation in high-quality childcare and preschool education.

Factors that pose risks to children’s understanding of objects include:

- adolescent parenthood
- maternal mental health problems during the antenatal and postnatal period
- maternal use of drugs, alcohol and tobacco during the antenatal period
- a preterm birth
- exposure to lead during the antenatal and postnatal period
- low family income
- low parental qualifications.

How is children’s object knowledge best assessed during the first five years?

Children’s early object knowledge is predictive of their later object knowledge. Methods for assessing children’s early object knowledge include:

- the problem-solving sections of the Ages and Stages Questionnaire between one month and three years
- the Bayley Scales of infant and toddler development for in-depth assessments of children’s object knowledge and motor development during the first three years
- the Pictures Similarities subtest from the British Abilities Scale for understanding children’s knowledge between the ages of three and six.

Details of further assessments are provided in the main report.

What are the implications for early intervention?

- During infancy, all caregivers should be made aware of the importance of object manipulation and exploration, and the value of caregiver and child object play.
- During toddlerhood, all caregivers should be made aware of the value of learning experiences outside of the home.
- During the later preschool years, all families can benefit from messages that highlight the importance of books for providing young children with information about object relationships, as well as toys and other learning materials, which support children’s knowledge of object categories and the use of objects as tools.
- Opportunities to play with objects and gain information about them should be made available through children’s centres and early childcare.

- Early years' curriculums should provide children with opportunities to learn about object characteristics, categories and systems.

Findings: Children's understanding of people (theory of mind)

What is it?

'Theory of mind' (ToM) involves the awareness that some objects are alive and conscious, that conscious beings have goal-directed intentions, and that individuals differ in what they know and understand. Children's ToM is typically understood through the child's ability to predict the thoughts of others based on others' knowledge, even if this knowledge happens to be different from what the child knows to be true.

What other competencies are associated with the development of children's theory of mind?

Children's ToM capabilities are associated with the development of the executive functions, children's early language capabilities and their ability to understand the causal relationship between their own thoughts and behaviours, and the thoughts and behaviours of others.

How does children's theory of mind impact their cognitive development over time?

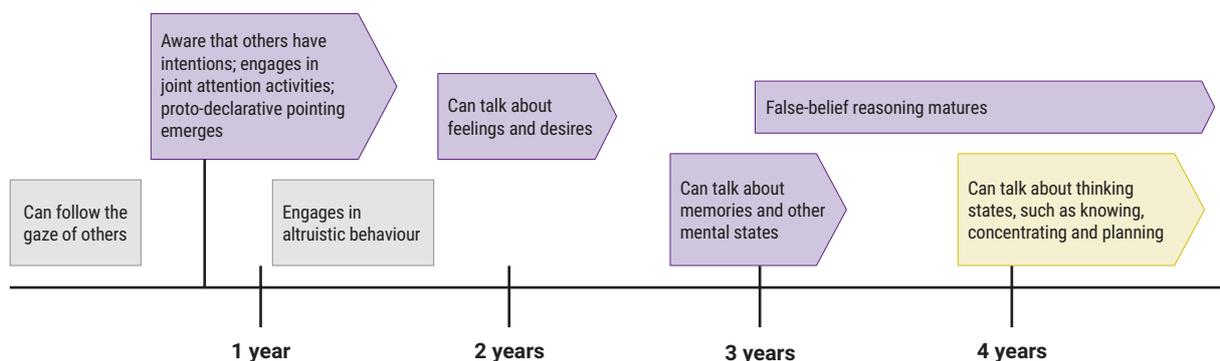
Children's ToM capabilities during preschool allow them to anticipate the thoughts and feelings of others and are believed to contribute to children's social skills. Studies show that ToM skills at age four predict children's popularity and friendships in primary and secondary school. ToM capabilities are also associated with children's sensitivity to teacher feedback, which in turn predicts their academic success.

How does children's ToM develop during the first five years?

Figure S2 provides an overview of the key milestones in children's ToM occurring during the first five years of life.

FIGURE S2

Milestones in the development of children's ToM during the first five years



Source: EIF

- Precursors to children's ToM understanding in infancy include a preference for human faces, higher-pitched vocal tones and the ability to track moving objects.
- At three months, most infants can follow the gaze of others.

- At nine months, most children are capable of sharing in joint attention activities with others. Joint attention reflects the understanding that others may have interests and knowledge that is worth understanding and sharing.
- The protodeclarative point (for example, pointing at an object or event), occurring at around 10 months, is also thought to be indicative of the infant's awareness that knowledge may be shared.
- Key ToM milestones occurring during the second year include spontaneous altruistic behaviours, as well as the use of 'mental-state' talk for sharing thoughts and feelings with others.
- By the end of the third year, most children can talk about past events and discuss events occurring in the future.
- Many four-year-olds are capable of manipulating the thoughts of others by telling sophisticated lies.
- During the fifth year, most children can fully predict the false beliefs of others. Children are also able to talk about more complex thinking states such as knowing, planning and concentrating.

What factors are associated with the development of children's understanding of theory of mind during the first five years?

Supportive factors associated with the development of ToM:

- treating the child as a valued member of the family through 'mind-minded' conversations during infancy and toddlerhood
- conversations about what people want, like and think – also referred to as 'mental state' talk
- having an older sibling within one and 12 years of the child's age.

Risk factors associated with the development of ToM:

- a genetic risk of autism
- speech and language delays
- low family income.

How is children's ToM best assessed during the first five years?

Methods for assessing children's ToM include items from the communication section of the Ages and Stages Questionnaire, as well as the Ages and Stages – Social, Emotional Questionnaire. In later preschool, a variety of other validated measures exist, including the Theory of Mind Inventory-2.

What are the implications for early intervention?

- Parents should be made aware of the value of mind-minded parenting behaviours throughout infancy and toddlerhood and mental-state talk, especially from the age of one onwards.
- Childcare providers should be encouraged to use mental-state talk with children.
- Preschool curriculums should be enhanced through content which increases children's awareness of others' feelings, intentions and perspectives.
- Targeted interventions should be made available to parents with a child identified as having an autism spectrum condition.

Findings: Children’s understanding of number

What is it?

The development of children’s numerical understanding involves their awareness of the concepts of more and less, the ability to count, basic addition and subtraction skills, and their understanding of the relationship between Arabic numerals and specific cardinal values. Children’s understanding of number is thought to operate through two systems:

- an approximate number system (ANS) which allows them to discriminate differences in magnitude
- a precise number system (PNS) which allows them to understand the precise value of numerosities of four or less.

What other competencies are associated with the development of children’s understanding of number?

Children’s numerical understanding is supported by the executive functions, and working memory in particular. Early number capabilities are also associated with children’s early language development and motor skills.

How does children’s early understanding of number impact their development over time?

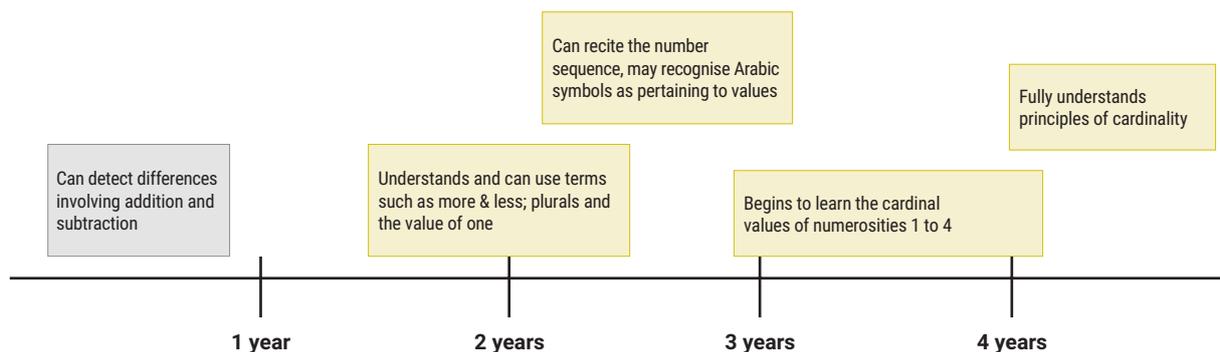
Children’s understanding of number during preschool is consistently associated with their mathematical achievement in primary and secondary school. Mathematical achievement in turn is consistently found to be the strongest predictor of children’s overall school achievement and their success in entering the workforce.

How does children’s understanding of number develop during the first five years?

Figure S3 provides an overview of the key milestones in children’s understanding of numbers occurring during the first five years.

FIGURE S3

Milestones in the development of children’s understanding of number occurring during the first five years



Source: EIF

- Infants have been found to discriminate differences in magnitude at ratios of 1 to 3 within hours of birth. Magnitude discrimination capabilities continue to improve throughout early childhood.
- Infants can also discriminate differences in small numbers between one and three, and this is associated with their rudimentary understanding of addition and subtraction principles.

- By the end of the second year, many toddlers understand the word one, the use of plurals, and words involving values such as 'many', 'more' and 'less'.
- During the third year, many children learn to recite the number list.
- By end of the third year, many children will have begun to learn the cardinal values associated with the words two through four. This learning is gradual, and the cardinal values are learned one at a time. Once children learn the word five, however, most children will be able to accurately apply the appropriate number name to the cardinal values of all numbers.
- Children's understanding of the counting principles at the end of reception is highly predictive of their mathematical achievement for the remainder of primary school.

What factors are associated with the development of children's understanding of numbers during the first five years of life?

Supportive factors associated with children's understanding of number:

- 'number talk' conversations with caregivers about small and large numerical values
- the frequency with which caregivers emphasise large numerical values
- the availability of formal numerical activities in the home
- enriching early years education, which includes activities that support children's understanding of Arabic numerals, the counting principles, and concepts associated with addition and subtraction.

Risk factors associated with children's early understanding of numbers:

- a preterm birth
- speech and language delays
- low family income.

How is children's understanding of numbers best assessed during the first five years?

Most assessments of children's numerical understanding are validated for children aged four and older. These assessments include the Early Math Diagnostic Assessment (EMDA) and the Test of Early Mathematical Ability. The problem-solving section of the Ages and Stages Questionnaire also includes questions involving children's understanding of numbers from 30 months onwards. However, mathematical difficulties are not typically diagnosed with any reliability until children enter primary school.

What are the implications for early intervention?

- All families are likely to benefit from messages regarding the importance of large and small number-talk in the home, as well as number-related play.
- Income-related differences in children's counting capabilities have been identified by age four and increase throughout primary and secondary school. Studies show that low-income children nevertheless have an informal understanding of numerical concepts that supports their learning of the counting principles. The ages of three to five are therefore considered an ideal time to rectify income-related learning gaps in children's understanding of numbers.
- Enriching preschool and reception curriculums which include content aimed at supporting children's understanding of the counting principles have good evidence of improving children's numerical understanding.

- Income-related learning gaps might further be reduced through strategies aimed at increasing the frequency of informal and formal mathematics activities in the home. Formal activities include those that support children’s understanding of the counting principles, and activities that increase children’s knowledge of Arabic numerals and number signs.

Findings: Children’s language development

What is it?

Language is traditionally defined as the systematic and conventional use of sounds, signs or written symbols for communication purposes and self-expression. Language provides children with an efficient means to represent and combine information from the environment in a way that can be communicated with others. Language initially develops as a result of children’s understanding of objects, people and numbers, but then fundamentally transforms children’s thought processes within each of these systems by providing children with words to describe and think about many of the core concepts fundamental to each cognitive system.

Language development is typically understood through four separate components:

- phonology involves the ability to perceive differences between sounds and words, as well as reproduce these sounds
- semantics refers to the knowledge of vocabulary
- pragmatics involves children’s knowledge of the communicative functions of language
- grammar involves knowledge of the rules which govern the ways in which words are put together in sentences to convey specific meanings.

What other competencies are associated with the development of children’s understanding of language?

Children’s language development is supported by their ability to understand the intentions of others. Language development is also reliant on children’s ability to detect patterns in human speech.

How does children’s early understanding of language impact their development over time?

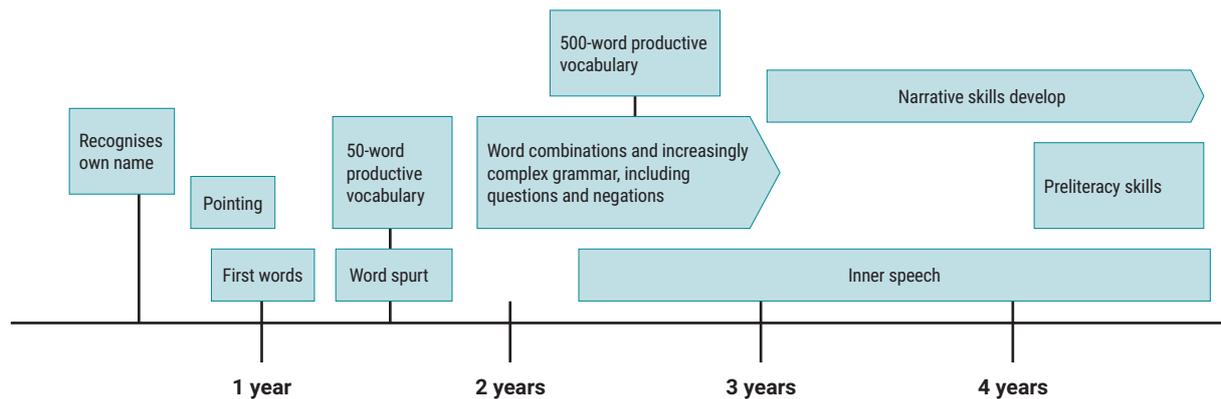
Children’s language capabilities are strongly associated with a wide variety of important child outcomes – including the three previous cognitive competencies described in this review – as well as children’s social, emotional and behavioural development. Once in school, children’s language capabilities are highly associated with their academic achievement and entry into the workforce.

How does children’s language develop during the first five years?

Figure S4 provides an overview of the key milestones in children’s language development during the first five years.

FIGURE S4

Milestones in the language development occurring during the first five years



Source: EIF

- Key milestones in children's receptive understanding of language during the first year include the ability to recognise their own name. This typically occurs between four and six months.
- Key milestones in children's expressive capabilities include the occurrence of reduplicative babbling, which typically occurs at around six months.
- The protodeclarative point is believed to suggest that the infant understands that he or she can communicate with others to gain or share information. Protodeclarative pointing frequently occurs during joint attention activities involving objects at around the time infants are 10 months old.
- Most children can say one or two words at the time of their first birthday.
- Children's vocabulary grows dramatically during the second year. Children can typically say approximately 300 words by the time of their second birthday.
- By the age of two, many children are putting words together in sentences.
- From the beginning of the third year onwards, children's word combinations become increasingly more sophisticated as their vocabulary continues to grow.
- During the third year, children begin to use inner speech to practise language and monitor their own behaviour.
- During the fourth year, children begin to converse with others in structured narratives.
- During the fifth year, children begin to acquire preliteracy skills associated with their school readiness.

What factors are associated with the children's language development during the first five years?

Supportive factors associated with children's language development:

- the child's mother was between the ages of 30 and 39 at the time of her child's first birth
- being firstborn
- being a girl
- high levels of age-appropriate infant-directed speech that is responsive to the child's specific interests
- frequent joint attention activities

- the availability of books in the home and shared reading
- degree-educated parents
- high family income
- childcare from one adult in the first two years
- participation in childcare from age two onwards
- enriching preschool education.

Risks associated with children's early language development include:

- adolescent motherhood
- high levels of stress or the existence of maternal mental health problems during pregnancy and postnatally
- maternal use of harmful substances
- a preterm birth
- low parental qualifications
- higher number of siblings

How are children's language capabilities best assessed during the first five years?

Parental reports of their child's early communication behaviours are considered to provide reliable estimates of children's verbal abilities during the first 14 months. The most widely used measures during the second year involve adaptations of the MacArthur Bates Communicative Development Inventories. Later in development, direct testing by a trained practitioner is required. Tests with particularly good reliability include the New Reynell and the British Picture Vocabulary Scales.

What are the implications for early intervention?

- Caregivers should be provided with information about the importance of infant-directed speech which is developmentally appropriate and responsive to children's needs, in addition to information about the importance of book sharing activities.
- Children can grow in and out of language difficulties throughout development. This means that children's language should be monitored on an ongoing basis from the age of two onwards, so interventions can be made available as and when needed.
- Children's language development is highly associated with caregiver qualifications and family income. Early intervention activities can therefore be effectively targeted on the basis of family income.
- Income-related language gaps are present already by 18 months and entrenched by the age of three. Early intervention activities aimed at reducing income-related language gaps should therefore start well before the child's first birthday.

Summary of key findings

- Studies consistently show that early cognitive competencies are predictive of later school achievement. In particular, cognitive capabilities at age four are reliable predictors of children's academic success from reception onwards.
- Studies show that highly nurturing and stimulating environments in the early years potentially protect children from poor cognitive outcomes as they grow older, whereas early experiences of disadvantage may place children at a developmental risk.

- Nurturing home learning environments include positive and sensitive parent–child interaction, enriching learning materials that include age appropriate books and toys, and enriching learning experiences outside of the home, which may include high-quality childcare and early years education.
- Frequent, high-quality infant-directed speech and behaviours which are responsive to the child’s developmental needs are found to make the greatest impact in supporting early cognitive and language outcomes.
- Income-related learning gaps are both wide and deep. These gaps are already present by the age of three (and in some cases even earlier) and then steadily increase as children grow older.
- Income-related learning gaps are not determined by one single factor, meaning that there is no single solution. Strategies for addressing income-related learning disparities must therefore be comprehensive and multifaceted.

A variety of factors other than family income are also associated with individual differences in children’s early cognitive development, including preterm birth and maternal mental health problems during pregnancy and after the child is born. These factors should therefore be incorporated as part of comprehensive, system-wide strategies which aim to support children’s cognitive development during the early years.

Recommendations

The earlier, the better

The evidence described in this review makes clear that individual differences in children’s cognitive development are evident from the first year onwards. **Early years services should therefore be optimised to support children’s cognitive development from the antenatal period onwards.**

- Activities that support children’s cognitive development during the antenatal period include those that target risks associated with a preterm birth and increase mothers’ access to effective mental health services.
- Activities with evidence of supporting cognitive outcomes during the first year include intensive home visiting interventions for families with pre-identified risks, including low family income.
- Activities found to support children’s cognitive development during toddlerhood include continued intensive home visiting support, as well as enriching childcare from the age of two onwards.
- There is preliminary evidence to support the use of various speech and language interventions for children identified as having language delays from the age of two onwards.
- There is good evidence to increase the availability of enriching and high-quality early years education for disadvantaged children starting at age two. The research described in this review suggests that early years curriculums may be enhanced through content that supports children’s understanding of the world and the relationships between objects, their ToM capabilities through stories and role play, their awareness of numbers through counting activities, and their understanding of language through activities which support preliteracy skills.

A comprehensive approach

Early learning gaps are multi-determined, meaning that there is no single solution. **Reducing income-related learning gaps therefore requires a comprehensive approach, providing age-appropriate support to all levels of need.** Family income should be a primary target of this support, although any comprehensive strategy should make use of individual assessments to further determine when and how early intervention services should be provided.

A role for everyone

The comprehensive approach described in the previous section identifies a prominent role for everyone involved in the delivery of early years services that support children's early cognitive development. This includes midwives, health visitors, GPs, speech and language therapists, educational psychologists, children's centres, childcare providers, nursery and preschool educators, intervention providers, academic researchers and early years' commissioners.

Strong support from central government is also crucial for supporting children's early learning needs, and efforts such as the recently announced 'Chat, Play and Read' behaviour change strategy for improving the quality of the home learning environment are warmly welcomed. However, the evidence described in this report tells us that behaviour change messages are simply not enough to improve the learning outcomes of the nation's most disadvantaged children. We therefore recommend that **central government increase its investment in health visiting so that the service can provide, alongside its universal offer, a package of intensive home visiting support for low-income families to support their young children's early learning needs.** The government's recent announcement to provide speech, language and communication training to health visitors is a welcome start.

We further believe that the 15-hour childcare offer for the most disadvantaged families represents a good opportunity to close income-related learning gaps. **We therefore recommend that the government considers enriching this offer through additional support for parents that is offered alongside and through the 15-hour childcare offer.** This support should be responsive to individual family needs and provide sufficient opportunities for parents to learn new skills for supporting the home learning environment. This support should also be augmented by evidence-based parenting interventions and other local family support services.

Moving forward

This review has summarised the most recent evidence regarding children's early cognitive development with the aim of improving the effectiveness of early years services and providing recommendations for reducing income-related learning gaps. This evidence suggests that there are no easy solutions, but there are some clear options for moving forward. These options include starting as early as possible, already during the antenatal period. We also emphasise the need for a strong commitment, both at the local and central level to make sure that sufficient resources are available so that these options are possible. While some of these options are clearly costly, they also stand the greatest chance of reducing income-related learning gaps in the short run, and increasing social mobility over time.

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