

Developmental Milestones: Cognitive Development

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Drs Wilks, Gerber, and
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disclosed no financial
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to this article. This
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Objectives After completing this article, readers should be able to:

1. List the foundational aspects of cognitive development.
2. Characterize object permanence, causality, and symbolic thinking.
3. Discuss the steps of problem-solving development.
4. Describe methods of assessing language development.
5. Review language milestones.

This is the second in a series of three articles on normal infant and child development. The previous article covered the acquisition of motor milestones. This article focuses on cognitive development. Social-emotional development will be discussed in the final article.

Introduction

Infant and child development relies on significant interdependence of the developmental streams. The infant who is concentrating on gross motor control while sitting is unlikely to be able to explore an object's detail or advance his or her manipulation of objects. The clinician must appreciate the total developmental progression of a child while also understanding the patterns of development expected within individual developmental streams. Such improved understanding of development can assist in the pediatrician's surveillance of a child's progress but will not substitute for a systematic developmental screening program, as outlined in recent American Academy of Pediatrics (AAP) Practice Guidelines. The complete table of developmental milestones is included in the online version of this article for reference (Table 1). The table is printed in the previous article of this series (*Pediatrics in Review*. 2010;31:267–277).

Cognitive Development

Cognitive development is the foundation of intelligence. The dictionary defines intelligence as the ability to learn or understand or to deal with new situations. In reality, intelligence is a broad concept that involves multiple factors and is incompletely understood. The best efforts to quantify this concept come through use of standardized intelligence tests that attempt to measure multiple areas, such as problem-solving, language, attention, memory, and information processing. Scores in these domains are used to determine specific subset strengths and weaknesses in addition to a composite score. The subset scores and composite score do not represent the individual in isolation accurately and require careful analysis. Accurate interpretation of intelligence testing requires more than a casual understanding of normal ranges.

Standardized intelligence testing is not available for infants. Therefore, the assessment of infant and child intelligence depends on progression through two developmental domains: problem-solving and language. Children advance through these domains by learning. Learning requires the ability to direct and to sustain attention as well as the ability to manipulate information.

The foundational aspects of cognitive development include memory, representational competence, attention, and processing speed. Successful cognitive development requires progress in all these domains. Memory involves the proper encoding, storing, and

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retrieving of information. Representational competence is the ability to create and manipulate a mental image of an object or idea that is not seen. Appropriate advancement in the control of attention—learning how to focus and shift focus—also is important. Processing speed may be the central limiting factor of intelligence because it links the other functions together.

Developmental Theory

Many theorists have tried to create a framework to understand better the cognitive development of infants and children. No categorization of developmental stages has been able to describe accurately what parents have been observing for centuries. The current overarching construct is that infants are not merely passive learners; they are very active in the observation and modification of their environment. Learning is a product of this observation and occurs when there is disequilibrium of assimilation (taking in information) and accommodation (revising existing mental structures). The cognitive development of an infant is no less predictable than the motor development described in the first article of this series. The progression, however, is more subtle, and child behavior often is mistaken as abnormal rather than evidence of advancement to a new developmental stage.

Object permanence is one of the subtle developments and is not an all-or-nothing phenomenon. It may be most noticeable around 9 to 10 months of age, when the infant understands that his mother still exists even when she is not visible. The object permanence is not yet mature enough, however, to allow the infant to make a judgment about where the mother might be when she is not visible, so he cries and demonstrates separation anxiety. By 15 to 18 months, the toddler's understanding has matured, and he will be able to make predictions regarding the mother's location. Rather than crying when separated, the child will use advancing motor skills to seek her out. Object permanence allows him to form concepts and ideas about things, even if the items themselves cannot be seen, and then to create schemes for relating to objects encountered in the future. For example, successfully interacting with a cup involves use of different skills than throwing a ball. The toddler's early organizational ability also allows him to separate objects into language-specific categories.

Causality refers to the infant's gradual understanding of her role in changing or acting on her environment. The infant discovers that she can use objects to her benefit; she even can use her voice to make objects (eg, her parents) respond in ways that directly meet her needs or wants (eg, being picked up). Her actions become

increasingly more intentional. Between 4 and 8 months of age, she purposefully begins to repeat effects that were discovered accidentally. For example, a random kick causes toys hanging over her activity mat to move, so she kicks again. Eventually, she will try different interactions to see what effects she can create.

Symbolic thinking allows for expansion of play by using one object to represent another object. The toddler may use blocks as cars and often reenacts past events. The toddler may “cook” his favorite food in a toy kitchen and use paper to represent his “food.” Imitation of the actions of others is an important part of play, and his food preparation reflects what he sees his caregivers do for him.

Object permanence, causality, and symbolic thinking are fundamental concepts in the current understanding of cognitive development. Such foundational skills combine with a toddler's gross and fine motor advancement to permit the ability to problem-solve and develop language.

Problem-solving

Problem-solving involves the manipulation of objects to achieve a specific goal. An infant's first exploration of her environment is performed visually. At first, the infant is able to follow a face and then objects. Tracking starts with horizontal and vertical movements but soon advances to tracking circular motion. Three-dimensional awareness and response is seen at 3 months, when an infant reacts to a visual threat. Initially, the infant only regards and stares intently, but as she gains improved control of her arms and hands, she begins batting at and reaching for objects. She begins to inspect items placed in her hand visually and by mouthing as a means of environmental exploration. As hand control improves, she is able to hold an object in one hand while manipulating it with the other. At around 5 months of age, her vision has matured to allow her to focus on smaller objects. Her attempts to pick them up help develop a pincer grasp and eventually lead to isolation of her index finger, which allows her to explore objects by poking.

With maturation of object permanence and causality, the toddler begins to play in earnest. She bangs objects and delights in the sound they make as well as in the reactions from her caregivers. When she drops something from her high chair, she is able to look down for it. Her attention span continues to increase, and she is able to work on obtaining objects that initially are partially hidden and then hidden completely. She works on removing lids and formulating different strategies for obtaining objects out of her reach. She soon begins to learn

through her manipulation instead of merely learning how to manipulate.

Language Development

Language is a broad concept that involves the representation of thoughts and ideas using culturally agreed-upon arbitrary signals for the exchange of ideas. Language encompasses both expressive and receptive processes. Language skills are the single best indication of intellectual ability, and evidence exists that early language skills are related to later reading skills. In fact, among school-age children who have specific language impairments, up to 50% also have a learning disorder involving reading.

Clinicians often assess language development incompletely by asking how many words a child knows, but speech, or vocal communication, is only one form of expressive language. Other forms include the use of gestures, manual signs, facial expressions, body postures, pictures, diagrams, and written symbols. Each of these has a strong cultural overlay, although some, such as facial expressions, can be understood more universally. The production of speech is a specific motor skill and requires complex control of air flow, mouth shape, and tongue position. Impairments in motor planning and execution or anatomic abnormalities can impair speech yet spare other language abilities. A hearing-impaired child using manual sign language can demonstrate normal expressive language without the use of speech. Rather than asking parents how many words their child uses, an alternative question is, “How does your child communicate with you?” The question can be clarified to ask how the child shows displeasure or happiness or requests a want or a need.

Receptive language is the ability to understand communication. It is evaluated most often by a response to a request or question. However, a request to perform a gross motor task by the child who has gross motor impairment, such as cerebral palsy, may give a false impression of a child’s receptive language skills. A more useful method of assessing receptive language is to ask how the child responds to parental communication. Language and social development are largely intertwined, and conversations regarding communication help the clinician survey both developmental domains.

Language development is molded by the type of interactions the infant has with his environment. Although the ability to learn language is innate, environmental exposure to language is essential. For example, an infant who has a significant hearing impairment can startle to sound, laugh, and even babble. The hearing

impairment would be easily missed by using observational measures alone, highlighting the importance of systematic hearing screening programs. With intervention by 6 months of age (eg, with hearing aids), language outcomes in children who have hearing impairments are similar to children who have no hearing deficits, emphasizing that exposure to language is the key to language development. The importance of language exposure is demonstrated most strongly and simply by children beginning to speak the language they hear, despite being born with the ability to learn any language. Children in Spanish-speaking homes learn to speak Spanish, not Russian. Ideally, the language to which they are exposed should be as rich and diverse as possible. Multiple studies have demonstrated that a robust linguistic environment is critical to language development. It is estimated that by the time a child starts kindergarten, the difference in word exposure between socioeconomic groups may be as much as 32 million words, making low socioeconomic status a risk factor for poor language development.

Interventional approaches, such as reading to infants and children, try to counter this risk by promoting increased frequency and complexity of linguistic exposure. Other, less successful strategies have involved “educational” videos. These videos fail to understand the interdependence of language and social development. Conversational turn-taking and appropriate communicative interaction is not provided through video or television media; these crucial aspects can be provided only by interactions with people who are present and responsive.

Language Milestones

Infants communicate long before they speak their first words or phrases. At birth, crying is the primary form of communication. It is nonspecific but very effective in initiating a response from a caregiver. Expressive communication then progresses through cooing and babbling. In a trial-and-error process, the infant begins making vowel and consonant sounds that she can put together into “mama” and “dada” by 9 months of age. Although she is not using the words discriminately, if her caregivers respond to the sounds she makes, she will continue to use them. As her attempts to communicate become more precise and the outcome more predictable, by her first birthday she can say her first word and can point to communicate a request. The first words attained often are labels for things with which the infant commonly interacts. There is great variety among children of the same age as to what words they use, emphasizing the importance that environmental stimulus plays in language development.

By 15 months, the toddler is able to give a clear “no” with a headshake. His ability to imitate sounds increases, and he can repeat an entire word and even mimic environmental sounds. By 18 to 24 months of age, he is starting to use pronouns such as “me,” and his vocabulary has expanded to 50 words. New words are learned quickly, and he begins to combine them into two-word phrases (noun + verb). He now is able to communicate basic wants (“more drink”) and social interest (“bye, mama”). Between 2 and 3 years of age, his vocabulary continues to increase, and the phrases he uses increase to 3 to 4 words in length. He begins asking “what” questions frequently. His ability to pronounce words also has improved, and by 2 years of age, at least 50% of his speech is understandable to a stranger. At 3 years of age, 75% is understandable, and the beginning of the “why” questioning occurs. He is able to tell others what he did while they were apart. His sentence structure continues to gain complexity, and by 4 to 5 years of age, his speech is completely understandable to strangers.

Although the infant’s expressive communication is more observable, receptive language skills also are present at birth. A neonate shows preference for voices and interest in faces. She will begin to turn toward sound. Early evidence of receptive language ability is her response to “no” and to her name. Once she can isolate her index finger she can work on pointing. By 12 to 15 months, she can point to body parts and familiar objects when named. Her understanding of grammar increases, and she is able to understand pronouns by 18 to 24 months. By 2 to 3 years of age, she can answer questions, understands the concept of “one,” and follows two-step commands. Her natural ability to categorize has matured, and by 3 to 4 years, she can point to an object in a requested category rather than just by name. She understands much of what is said, including negatives. Her ability to follow complex instructions continues to improve as she begins to prepare for early school experiences.

Developmental Red Flags

At every pediatric encounter, some form of developmental surveillance occurs. The interaction of the child with the caregiver or examiner often is measured against what is expected. Such surveillance may include questions regarding specific developmental milestones, but it does not substitute for developmental screening using standardized instruments. Recognition of certain key developmental red flags is important, however. Table 2 lists red flags specific to the cognitive domain. If a red flag is

Table 2. Cognitive Red Flags

Age	Red Flag
2 months	Lack of fixation
4 months	Lack of visual tracking
6 months	Failure to turn to sound or voice
9 months	Lack of babbling consonant sounds
24 months	Failure to use single words
36 months	Failure to speak in three-word sentences

discovered during an examination, a developmental and medical evaluation is indicated. Early developmental intervention services also may be warranted. Although it may be appropriate to use developmental screening tools to uncover additional areas of concern, these tools should not take the place of a developmental and medical evaluation. Additional information on using screening instruments and performing developmental surveillance can be found in the Recommended Reading (AAP Policy Statement: Identifying Infants and Young Children with Developmental Disorders in the Medical Home: An Algorithm for Developmental Surveillance and Screening).

Conclusion

The cognitive development of a child is an exciting process for both the child and the parents. The child demonstrates remarkable skills in communication and problem-solving. Such skills are not isolated and are demonstrated best in the context of the child’s social and emotional development. The next article in this series will describe that domain, completing the picture of normal development.

Suggested Reading

- Council on Children With Disabilities, Section on Developmental Behavioral Pediatrics, Bright Futures Steering Committee, Medical Home Initiatives for Children With Special Needs Project Advisory Committee. Identifying infants and young children with developmental disorders in the medical home: an algorithm for developmental surveillance and screening. *Pediatrics*. 2006;118:405–420
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