The term **cognitive development** refers to age changes in the ability to acquire, manipulate, or reason about information in particular contexts. When the intellectual capacities of at least two age groups are compared and the oldest group has not yet reached middle age, changes in performance are usually for the better, in the sense that they reflect improvements of one kind or another (e.g., those in the older group recall more information; those in the older group draw more appropriate inferences). It is not possible to summarize all of the details of what is known about cognitive development in a single brief article. Readers interested in more comprehensive treatments should consult sources such as Byrnes (2008), Bjorklund (2004), or Siegler and Alibali (2004). In the present overview, some general age trends in the structural and functional aspects of cognition are presented in order to provide a sense of the kinds of important and influential changes that occur.

### Changes in Structural Aspects of Cognition

In a structural analysis of some physical or mental system, the focus is on the component parts of the system and how these parts are organized and interrelated. In a functional analysis, on the other hand, the emphasis is on the activity or operation of the system to achieve certain goals. These two perspectives are intrinsically related to each other because the component parts both determine and place constraints on the way the system can carry out tasks or operations. For example, the fact that the human heart has several kinds of chambers arranged in a particular way (a structural analysis) determines how blood can circulate through the body (a functional analysis). In the case of cognition, there are two structural features that both subord and constrain the performance of mental processes: knowledge and processing capacity. When people have more knowledge and more processing capacity, they can perform a wider array of mental tasks and do so more accurately and efficiently. In what follows, age changes in these two structural aspects are summarized.

### Knowledge Changes

The term **knowledge** refers to three kinds of information structures that are stored in long-term memory: declarative knowledge, procedural knowledge, and conceptual knowledge (Byrnes, 1999). Declarative knowledge, or “knowing that,” is a compilation of all of the facts that a person knows in various domains (e.g., George Washington was the first U.S. President; the answer to the problem “3 + 2” is “5”). In contrast, procedural knowledge, or “knowing how to,” is a compilation of all of the procedures that a person knows how to perform (e.g., knowing how to ride a bicycle, knowing how to solve math problems). Conceptual knowledge, or “knowing why,” pertains to a person's understanding of facts, procedures, and systems (e.g., knowing why humans are classified as mammals; knowing why 7/12 is the answer to 1/3 + 1/4).

Across a variety of domains, numerous studies have shown that declarative, procedural, and conceptual knowledge increase between infancy and adulthood (Byrnes, 2008). For example, consider the large-scale national assessments that are regularly conducted by the federal government (i.e., the National Assessment of Educational Progress or NAEP). About every two years, the NAEP studies measure the
school-related competencies of thousands of 4th, 8th, and 12th graders in subject areas such as reading, writing, math, science, history, geography, and civics. Regardless of the domain, there is clear evidence of knowledge accumulation with age on any given NAEP. However, the largest increases are for declarative and procedural knowledge. Even among 12th graders, the majority of children fail to demonstrate a deep conceptual understanding of the core topics. When grouped into levels of performance such as “basic,” “proficient,” and “advanced,” most children are categorized or placed into the “basic” level.

One reason for the low level of conceptual knowledge evident in 12th graders is the abstract, multidimensional, and counterintuitive nature of the most advanced concepts in each domain. Even when teachers try their best to explain topics such as scarcity, civil rights, diffusion, limit, and conservation of energy, many children have difficulty understanding these topics. Compounding the relative lack of conceptual knowledge is the fact that children often develop misconceptions as well. For example, the scientific concept of force that is presented in physics courses is very different from children’s everyday concept of force; in addition, their everyday concepts tend to be very resistant to change.

This is not to say, however, that one cannot find the rudiments of sophisticated ideas even in very young children. A number of scholars argue that children come into the world equipped with the ability to acquire foundational notions in domains such as physics, mathematics, biology, and psychology (Gelman, 1998). Using very clever experimental techniques, preschoolers have been found to possess surprising insight into psychological concepts (e.g., that human behavior can be predicted from a person’s beliefs and desires) and biological concepts (e.g., that invisible germs are the cause of illness). Nevertheless, these rudimentary conceptions are a far cry from the sophisticated ideas children will need, but often fail, to master in their courses as middle school, high school, and college students.

**Capacity Changes**

In addition to knowledge, the second structural feature that influences the ability to perform mental tasks is processing capacity which is usually characterized in the form of working memory. When engaged in some mental task (e.g., performing a math calculation, evaluating several career options), an individual has to hold a certain amount of information in mind until the task is completed (e.g., the answer is derived, a career is decided upon). Complex problems require more processing capacity because more items of information need to be considered simultaneously and sequentially over time. Similar to what was reported above for knowledge, developmental studies of working memory show that there are monotonic increases in the ability to hold and attend to items in memory as children progress through the preschool, elementary school, and high school periods (e.g., Swanson, 1999).

**Changes in Functional Aspects of Cognition**

Functional aspects of cognition include any mental processes that alter, operate on, or extend incoming or existing information. Examples include learning (getting new information into memory), retrieval (getting existing information out of long-term memory), reasoning (drawing inferences from single or multiple premises), and decision making (generating, evaluating, and selecting courses of action). Given the intrinsic connection between structural and functional aspects of cognition, it is expected that older children would show better performance on learning, memory, reasoning, and decision-making tasks than younger children because knowledge and processing capacity increase with age. As detailed next, many studies have confirmed this expectation.
Learning and Retrieval

The primary method used to show that an individual has learned something is to show that he or she can recall the information on some kind of test. Hence, learning and retrieval are inherently interconnected (Anderson, 2004). As such, it makes sense to discuss age trends for both processes in the same section.

The literature on expertise shows how experts recall considerably more from a domain-relevant situation than novices because the former can use their extensive knowledge to encode the situation as a meaningful whole (Ericsson, Charness, Feltovich, & Hoffman, 2006). Thus, it is to be expected that older children would naturally recall more than younger children in most situations since older children have more knowledge than younger children. Numerous studies show this to be the case. In addition, older children, adolescents, and adults are more likely than younger children to use effective memory strategies to recall information (Bjorklund, 2004). Finally, older children can devote more of their attentional resources to a situation because (1) older children process information more quickly than younger children; (2) older children have greater working memory capacity than younger children; and (3) skills are more likely to be automated in older children than in younger children (due to differences in the amount of practice). Differences in knowledge, strategy use, speed of processing, and working memory capacity all contribute to substantial differences in learning and memory performance between older and younger children (Bjorklund, 2004; Siegler & Alibali, 2004).

Reasoning

Whenever individuals draw inferences from one or more items of information, they engage in reasoning. Scientists have investigated age differences in both domain-general categories of reasoning those that can be applied to multiple domains (e.g., deductive and inductive reasoning), and domain-specific forms of reasoning (e.g., mathematical reasoning, scientific reasoning, historical reasoning). Deductive reasoning consists of reasoning from a set of initial premises to a conclusion that logically follows from the premises (e.g., Premise 1 = John is taller than Bill. Premise 2 = Bill is taller than Mary. Conclusion: Therefore, John is taller than Mary). Inductive reasoning, in contrast, involves generating a general conclusion or rule from specific instances (e.g., speakers put “-s” on the end of “dog” to make it plural and at the end of “cat” to make it plural; therefore the rule is to put “-s” onto any noun to make it plural). Reasoning within domains reflects specific forms that may not have analogous counterparts in other domains. For example, the ways in which students reason from knowns to unknowns on a math problem is not exactly comparable to the ways in which students engage in scientific reasoning to set up experiments that reveal the cause of some outcome. Similarly, the ways in which scientists reason from evidence to causes is not exactly comparable to the ways in which historians reason about documentary evidence to conjecture about the events that may have transpired on a particular date.

Studies have shown improvements in all forms of reasoning between the preschool and adulthood periods (Byrnes, 2008; Markovits & Barrouillet, 2004). For example, whereas young children can draw some kinds of deductive inferences when given considerable scaffolding from adults, older adolescents and adults can draw a broader range of deductive inferences on their own. In the content areas, children progress from relatively primitive forms of scientific and historical reasoning in elementary school, to more sophisticated kinds of reasoning by the end of adolescence (Byrnes, 2008). Nevertheless, a number of studies have shown that even adults fall prey to a variety of reasoning fallacies. Thus, while reasoning performance improves with age, it is far from perfect in adulthood.
Decision Making

Decision making involves the generation, evaluation, and selection of options that can be used to attain goals (e.g., reading college guides to decide which schools to apply to). Although relatively few studies have examined the decision-making skills of children and adolescents, enough studies have been conducted to draw the following tentative conclusions: Older adolescents and adults seem to be more likely than younger adolescents or children to (1) understand the difference between options that are likely to satisfy multiple goals (e.g., a car that gets both good gas mileage and has a good repair record) and options that are likely to satisfy only a single goal; (2) anticipate a wider range of consequences of their actions; and (3) learn from their decision-making successes and failures (Byrnes, 2002). Nevertheless, as was noted above for reasoning studies, there are quite a large number of studies that show the various limitations of decision-making skills in adults (Jacobs & Klaczynski, 2005).

Metacognition

One further development that occurs during the childhood and adolescent periods is an increased ability to reflect upon one’s own thought processes and treat thinking as an object of thought (Bjorklund, 2004). This metacognitive ability can help older adolescents and adults see the errors of their ways and possibly avoid reasoning problems in the future. Collectively, the changes in structural aspects, functional aspects, and metacognition transform children into adults who have most of the skills they will need to be successful. Some adults are more successful than others, so the task remains to understand how individual differences in cognitive abilities emerge so that interventions can be created to help all individuals be successful.

See also

Child Psychology; Emotional Development; Social Cognitive Development.

References


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