UNIVERSITY OF LINCOLN

theuniversitylibrary&learningresources

Copyright Notice

Staff and students of this University are reminded that copyright subsists in this extract and the work from which it was taken. This Digitial Copy has been made under the terms of a CLA licence which allows you to:

- access and download a copy
- print out a copy

This Digital Copy and any digital or printed copy supplied to or made by you under the terms of this Licence are for use in connection with this Course of Study. You may retain such copies after the end of the course, but strictly for your own personal use.

All copies (including electronic copies) shall include this Copyright Notice and shall be destroyed and/or deleted if and when required by the University.

Except as provided for by copyright law, no further copying, storage or distribution (including by e-mail) is permitted without the consent of the copyright holder.

The author (which terms includes artists and other visual creators) has moral rights in the work and neither staff nor students may cause, or permit, the distortion, mutilation or other modification of the work or any other derogatory treatment of it, which would be prejudicial to the honour or reputation of the author.

Unit Code: SOW 1035M

Book Title: An introduction to child development

Name of Author(s):Keenan, T

ISBN: 0761962204

Year of publication: 2002

Place of Publication:London

Publisher: Sage

Title of extract:: Coginitve development

Author of extract:: Keenan, T

Page numbers of extract: 118-145

Name of Visual creator (as appropriate): J Gibson

Name of Designated Person authorising scanning: K Cooper

If obtained as copyright cleared please include:

Date obtained: ILL Request Number:

© University of Lincoln 2008

6 Cognitive Development

LEARNING AIMS

At the end of this chapter you should:

- **be able to describe the three theories of cognitive development covered**
- **understand and be able to define the key concepts of Piagetian theory, including *adaptation*, *organization*, *equilibration*, *assimilation*, and *accommodation***
- **be familiar with the four stages of development described by Piaget**
- **be aware of evidence both for and against Piaget's theory**
- **understand and be able to define the key concepts of Vygotskian theory, including *elementary* and *higher mental functions*, *internalization*, *zone of proximal development* and *scaffolding***
- **be aware of evidence both for and against Vygotsky's theory**
- **describe the model of the human information processing system covered**
- **understand and be able to define the key concepts of the information processing approach including, *long-term* and *working memory*, *encoding*, *automatization*, and *m-space***
- **be able to articulate some of the similarities and differences between the three theories**

Introduction

Cognition is the study of the thought processes or mental activity by which we acquire and deal with knowledge. The study of human cognition is a vast field, encompassing an extremely wide variety of topics. Examine any cognition textbook and you will find chapters on memory, attention, language, social cognition, reasoning, problem solving, and more. While, ideally, we would review each of these topics, it is simply impossible to do so in one

chapter (especially in a book not devoted entirely to cognitive development). Therefore, in this chapter, we will cover three of the most influential theories of cognitive development – the work of Jean Piaget, Lev Vygotsky, and information processing views on cognitive development. Within the discussion of each of theory we consider some of the key aspects of cognitive development across childhood.

Piaget's theory of cognitive development

Piaget's theory of cognitive development is considered the most important to emerge from the study of human development (Siegler, 1998). It is perhaps the most controversial theory as well (Beilin, 1992), since Piaget's theory and ideas are still at the centre of debate in developmental psychology. Ultimately, whether you agree or disagree with his position, the student of human development needs to understand Piagetian theory in order to understand the field of cognitive development. Thus, we start this chapter with a survey of Piaget's theory of cognitive development.

According to Siegler (1998), there are a number of reasons for the longevity of Piaget's theory. First, Piaget's observations of children provide a remarkable 'feel' for what cognitive development looks like. Second, Piaget's theory addresses fundamental questions that are of interest to philosophers and lay people alike. Piaget's theory attempts to provide answers to questions such as 'what is intelligence?' and 'how do we develop knowledge?' Finally, Piaget's theory was notable for its breadth, drawing together seemingly unrelated aspects of development under a coherent theory.

However, the fact that Piaget's theory has been influential in the study of cognitive development does not mean it has been accepted uncritically. A number of serious problems with Piagetian theory have been identified. We will review some of these at the end of this section, but where the research bears on a specific stage of development, we will review evidence that runs counter to Piagetian theory.

An overview of Piagetian theory: key concepts

In contrast to the assumptions of behaviourist theories, that children developed in reaction to their environment and the rewards and punishments it provided, Piaget argued that children actively explore their world, and their thoughts are ultimately derived from the child's actions on the world. Piaget believed that children *construct* their reality as they manipulate and explore their world; what children actually construct are cognitive structures which Piaget termed **schemes**. A scheme is an interrelated set of actions, memories, thoughts or strategies which are employed to predict and understand

the environment. Gardner (1973) elaborates this concept, arguing that a scheme is the aspect of an action or a mental operation which can be repeated with or generalized to a similar action or operation. Schemes form the basis for organizing one's reactions to the environment. As children grow, they develop and refine their schemes.

Piaget's early training was in the field of biology. Central to his theory are two biological concepts, **adaptation** and **organization** (Ginsburg & Opper, 1988). Organization refers to the individual's tendency to organize their cognitive structures or schemes into efficient systems (Lutz & Sternberg, 1999). Organization can take place independently of interaction with the environment. Children naturally begin to link together schemes, creating a more organized and interrelated cognitive system. For example, infants eventually begin to link together schemes developed for reaching, grasping, and sucking objects, combining these into more complex structures that can be generalized to other situations, and, thus, further their ability to negotiate the environment. Initially, they cannot combine these actions but through the process of organization, they are able to do so. This brings us to the concept of adaptation.

Adaptation involves the creation of cognitive structures or schemes through our interactions with the environment, allowing us to adjust to the demands posed by the environment. Adaptation takes place through two complementary processes called **assimilation** and **accommodation** (Piaget, 1952). Assimilation refers to the process of integrating the environment into one's current psychological structures (Lutz & Sternberg, 1999). That is, assimilation uses current schemes to interpret new knowledge. When we assimilate something, we mould it to fit in with our existing structures. Accommodation is the opposite process; it occurs when old schemes are adjusted to better fit with the demands of the environment. Assimilation and accommodation often operate simultaneously (Ginsburg & Opper, 1988). Consider the following illustration of how this process works: the infant sees a circular ring; the infant can assimilate this new object into their experience, applying their grasping scheme. Now the infant encounters a much smaller object such as a plastic token. The child cannot grasp it using their standard grip. They are forced to accommodate to the object, altering their grip so as to be able to pick up the token and continue their exploration.

Piaget believed that development occurred as a result of our predispositions to organize and adapt to new experiences. However, there are times when our cognitive structures tend to remain in one state more than another. At some points in time, we will be able to assimilate most new experiences, whereas at others, we will be forced to accommodate and adapt our structures to the environment. Piaget argued that when we can assimilate changes in the environment we are in a state of cognitive *equilibrium*, a 'steady state'

which our system aims for. However, when we are forced to accommodate we enter into a state of cognitive *disequilibrium*. States of disequilibrium force us to modify our cognitive structures so that we can assimilate changes and regain equilibrium. Piaget referred to this continual balance between achieving states of equilibrium and disequilibrium as **equilibration** (Piaget, 1952). The process of equilibration leads to the development of more efficient cognitive structures (Lutz & Sternberg, 1999).

Piaget noted that the organization of cognitive structures occurs in **stages**. For Piaget, a stage of development is a period in which the child's cognitive structures are *qualitatively* similar. Piaget also maintained that stages had two important characteristics. First, they occur in an *invariant* order in development; that is, stages are not missed, and children move through them in a fixed order. Second, stages are *universal*, in that they are applicable to all children and are not affected by cultural or social norms. While children may progress through the stages at different speeds as a function of inherited traits or particular environmental influences (Piaget, 1926), the nature of the stages through which they progress does not change. Piaget postulated four stages of development. We will consider each of these stages in turn.

The sensorimotor stage The **sensorimotor stage** encompasses the first two years of an infant's life. During the sensorimotor stage of infancy, children move from responding to the environment in a simplistic, reflexive manner, to being able to think about the environment using symbols. According to Piaget (1954), the major achievement of the sensorimotor stage is the development of **object permanence**. This is the idea that objects continue to exist independently of our ability to perceive them or to act on them. Object permanence is important, as it signals the beginnings of the ability to think using representations rather than through actions. In what follows, we consider each of the six substages (see Table 6.1).

Piaget (1952) argued that the sensorimotor stage of development is comprised of six substages. The first substage, *reflexive schemes*, runs from birth to 1 month of age. For Piaget, newborn behaviour consisted of little more than reflex behaviours. Development during this stage consists of the infant gaining control over these reflex behaviours and practising them. The second substage, *primary circular reactions*, runs from about 1 to 4 months of age. During this stage, infants begin repeating chance behaviours that lead to satisfying results, developing simple motor habits such as sucking their thumbs and opening and closing their hands. Piaget termed these behaviours **primary circular reactions**. Additionally, infants start to vary their newly acquired behaviours in response to environmental demands, as, for example, when they open their mouths differently to a nipple than to a spoon. In other words, they show a limited ability to anticipate events.

TABLE 6.1 Piaget's stages of sensorimotor development

Substage	Age	Significant accomplishments and limitations
Sensorimotor stage	0–2 years	*Infants initially understand the world via action but gradually develop the ability to use symbolic representations*
• Reflexive schemes	0–1 months	Infants gain control over and practise reflex behaviours
• Primary circular reactions	1–4 months	Infants repeat chance behaviours that lead to satisfying results (e.g., thumb sucking), and show a limited ability to anticipate events
• Secondary circular reactions	4–8 months	Infants can combine single schemes into larger structures (e.g., repeatedly grasping and shaking a rattle). This behaviour is not goal directed, however
• Coordination of secondary circular reactions	8–12 months	Secondary circular reactions are combined into new actions, and become intentional. For example, infants can coordinate a means and a goal
• Tertiary circular reactions	12–18 months	Infants begin to repeat actions and vary them in a deliberately exploratory manner. Can solve the **A-not-B** task and develop **object permanence**
• Invention of new means through mental combinations	18–24 months	Onset of the child's ability to think symbolically and mentally represent reality. Also heralds the beginning of **pretend play**

Substage 3, *secondary circular reactions*, runs from 4 to 8 months of age. Now infants perform actions that are more definitely oriented towards objects and events outside their own bodies, what Piaget termed **secondary circular reactions**. Using the secondary circular reaction, they try to maintain, through repetition, interesting effects produced by their own actions, such as creating a sound with a rattle. During this stage, infants move beyond employing one scheme at a time, and begin to combine schemes into larger structures, for example, grasping and shaking. Although they are a great cognitive advance over the previous stage, secondary circular reactions are limited in that they involve undifferentiated connections between actions and objects. Piaget did not view the infant's behaviour as goal directed or *intentional*; infants simply repeat newly acquired actions with respect to that object.

In substage 4, *coordination of secondary circular reactions* (which runs from 8 to 12 months of age), previously acquired secondary circular reactions are combined into new action sequences that are intentional and goal directed. A clear example is provided by Piaget's object hiding tasks, in which he showed the infant an attractive object which was then hidden under a cloth cover or beneath a cup. By substage 4, infants could set aside the obstacle and retrieve the object, coordinating two schemes: a *means* (pushing aside the cup) and a *goal* (grasping the object). Piaget regarded this means–end behaviour as the first truly intelligent behaviour and the foundation of all

later problem solving. Also, the fact that substage 4 infants can retrieve a hidden object indicates that they have achieved some appreciation of object permanence. However, Piaget believed that infants' understanding of object permanence is limited at this stage. He claimed that, if an object is moved to a new location, infants of this level of ability will still search for the object in the place in which it was first concealed, revealing that they do not view the object as existing independently of their actions on it. Finally, at this stage infants begin to show a tendency to engage in the *imitation* of behaviour.

From 12 to 18 months of age, infants progress through substage 5, *tertiary circular reactions*, in which they begin to repeat actions and to vary them in a deliberately exploratory manner. In doing so, infants try to provoke new results, as they quickly habituate to results that they are familiar with and are no longer satisfied with them. At this stage, infants can solve the **A-not-B task**. In this task, infants search for hidden objects, but after a set number of trials where they search for an object at one location (the A trials), the object is hidden in a second location (the B trial). Substage 4 infants will continue to search at A on the B trial, whereas substage 5 infants correctly search for the object at the new location. Another aspect of this stage is that infants can imitate more complex and unfamiliar behaviours. Infants also exercise their schemes in play when, for example, they bang blocks together in different ways or drop toys (or food) from their high chair on purpose. Finally, infants begin to distinguish themselves and their own actions from the world around them, showing the first signs of a developing sense of *self* (demonstrated through performance on the *rouge test* – see Chapter 9).

Infants typically reach substage 6, the *invention of new means through mental combinations*, at 18 months (lasting through to 2 years of age). Substage 6 marks the onset of the child's ability to think symbolically, that is to use mental representations of reality. Thus, at substage 6, the infant can think 'in their heads' before they act. In other words, they are able to combine symbols or representations in their heads rather than being tied to acting them out in sensorimotor behaviour, as in the previous stages. At substage 6, infants engage in *deferred imitation*, copying the *past* behaviour of models. As well, infants can pass *invisible displacement tasks*, a more advanced version of the A-not-B task. Finally, at substage 6, infants engage for the first time in **pretend play**, where they act out imaginary activities, and use real objects to stand for imagined objects.

EARLY UNDERSTANDING OF OBJECT PERMANENCE Renee Baillargeon and her colleagues (Baillargeon, DeVos, & Graber, 1989) have found results which stand in sharp contrast to Piaget's findings. Using a violation-of-expectation paradigm, Baillargeon examined infant's understanding of object

permanence in 5½-month-old infants. Her study involved two phases: in the first phase, infants watched as two cardboard rabbits moved from a position on one side of screen, and travelled behind the screen (out of the infant's sight), to appear on the opposite side of the screen. Infants watched two types of events in this phase, one involving a short rabbit and a second with a tall rabbit. After infants were habituated to these two displays, they entered into the second phase of the experiment. In this phase, the short and tall rabbits moved behind a screen which had a 'window' cut out in the middle. The window was designed to be high enough so that the tall rabbit would be seen when passing behind the screen while the short rabbit would not appear in the window, remaining invisible while behind the screen. Infants watched two further events in the second phase, a *possible event* and an *impossible event.* In the possible event, a short rabbit moved behind the screen in the same fashion as before, not appearing in the window. In the impossible event, the tall rabbit moved behind the screen and appeared on the other side in the usual fashion, but also did not appear in the window. Baillargeon et al. measured infants' looking times to these two events. Infants did not look any longer at the possible event than they did at the short rabbit in the first phase of the experiment, indicating they remained habituated to the possible event. However, infants dishabituated to the impossible event, looking at this event much longer than they did in the first phase of the study. This finding indicates that the infants recognized that the tall rabbit should have appeared in the window while behind the screen, suggesting that these very young infants have an understanding of object permanence. That is, they understood the tall rabbit continued to exist when occluded by the screen and therefore should have remained in view when passing the window.

The findings of this study and many others (Baillargeon, 1987; 1991; Baillargeon & Graber, 1988; Spelke, Breinlinger, Macomber, & Jacobson, 1992) have shown that infants have a great deal of knowledge about objects and their properties. Moreover, this research has shown that infants seem to come equipped with a rich understanding of the physical world. According to Piaget, this is knowledge infants should not possess until they are much older and able to engage in means–end reasoning. How can we reconcile these results? Ahmed and Ruffman (1998) have suggested that the knowledge tapped by object permanence tasks which employ looking as the measure of understanding may reveal a different type of knowledge than tasks like Piaget's A-not-B task which require the infant to manually search for the hidden object. They distinguish between **implicit knowledge** and **explicit knowledge**. Roughly speaking, explicit knowledge is knowledge which is accessible to consciousness (that is, you can reflect on it) whereas implicit knowledge is knowledge which is not accessible to consciousness but which still plays a role in guiding behaviour. The impossible event paradigms of

Baillargeon et al. may reveal implicit knowledge. In contrast, Piaget's A-not-B task focused on the development of explicit knowledge.

The preoperational stage The preoperational stage of development characterizes children's thinking between 2 to 7 years of age. The major change observed in children's thinking during this period of development is in the growth of representational abilities. Children make great strides in their use of language, number, pictorial representation, spatial representations, and pretend play. Rather than cover development within each of these areas, we focus instead on some key characteristics of children's thinking during the preoperational stage of development.

While children do make much progress in their ability to use representational thought, Piaget focused more on the *limitations* of the preoperational child's thought than on what they accomplish during this stage of development (Beilin, 1992). One of these limitations upon which Piaget focused is what he referred to as **egocentrism**. Egocentrism refers to the child's tendency to think only from their own perspective; egocentric thinking fails to consider other viewpoints. According to Piaget, the preoperational child's thought is egocentric in nature. To demonstrate this quality of preoperational children's thinking, Piaget employed a task called the 'three mountains task' (Piaget & Inhelder, 1956). In this task, the child sits on one side of a table upon which is a three-dimensional model of a number of mountains and some distinctive landmarks such as a cross and a house. Importantly, some landmarks can only be seen from certain perspectives and children were allowed to experience this for themselves by walking around the entire table. The child was then seated on one side of the table and a doll was placed on the opposite side. The child's task was to choose from a set of photographs which best described what the doll could see. Before the age of 6 or 7, children have great difficulties with this task and often respond by picking the photograph which is consistent with their own point of view.

According to Piaget (1926), another aspect of preoperational children's thinking is that it is **animistic**. Animistic thinking refers to the tendency to attribute life-like qualities to inanimate objects such as plants, rocks, or the moon. For example, young children may believe that the moon follows them while driving, or that picking a flower might hurt it. In Piaget's view, animistic thinking was a consequence of the child's tendency to think egocentrically. Animistic thinking declines during the preoperational stage as children acquire a better understanding of the world.

Another important limitation in preoperational children's thinking is the inability to employ mental **operations**. An operation is a procedure that can be carried out on some mental content. For example, preoperational children fail to understand a simple operation like **reversibility**, the idea that a

transformation can be reversed by carrying out a second transformation which negates the first. For example, if you have no apples and are given two apples, you can reverse the transformation by subtracting two apples to get back to the original state.

Piaget tested children's ability to employ operations using the **conservation task**. The conservation task tests children's understanding that the physical characteristics of an object or substance or quantity remain the same even though their physical appearance may change. A classic demonstration of the conservation task uses three glasses. Children are presented with two identical glasses, tall and thin in shape, each of which contains an identical amount of water. The experimenter takes one of these glasses and empties it into a third glass which is short and wide. The child is then asked which glass has more water, less water, or the same amount of water as the water remaining in the original tall, thin glass. In this example, the preoperational child will usually answer that the tall, thin glass has more water. They recognize that no water was taken away from or added by the experimenter, yet they insist that the amount of water has changed. Children's failure on this task illustrates a number of the characteristics of preoperational thought. First, the preoperational child's thinking is bound by the perceptual characteristics of the task; that is to say, they focus on appearances rather than on the nature of what occurs. A related characteristic is what Piaget called **centration**. Centration in the preoperational child's thinking leads them to focus on only one characteristic of the task. In our example, the child centres on the *height* of the water in the glass, a perceptual characteristic. Most importantly, children's failure on the task illustrates their inability to reverse the transformation which created the situation; the failure to understand the reversibility of the transformation leads them to mistakenly infer the quantity of water in the glass has changed. Only with the ability to carry out mental operations such as reversibility do children pass the conservation task.

Much like his work on sensorimotor development, Piaget's thoughts on the preoperational stage have also been criticized. For example, using a simplified version of the three mountains task, Borke (1975) showed that Piaget exaggerated children's difficulty with the task, suggesting that they are less egocentric than he may have thought. Research on children's developing social cognition – that is, their *theory of mind* (see Chapter 9) – supports this view, showing that by the preschool years, children are quite adept at perspective taking, recognizing for example, that people can hold different beliefs about a situation or that a person's belief might differ from reality (Wimmer & Perner, 1983).

Similarly, Piaget may have overestimated how much animistic thinking children engage in. By kindergarten, few children attribute the characteristics of living things to inanimate objects (Carey, 1985). Children's incorrect

responses tend to result from their lack of knowledge about living things and suggests that they have a theory of what 'alive' means that is different in some respects from the adult norm. Finally, research has suggested that preoperational children can be trained to understand concepts such as conservation (Beilin, 1978), suggesting that Piaget's belief that the development of operational thought is absent in one stage and present at another is incorrect. In summary, research on preoperational thinking has suggested that children's thought is far more complex than Piaget believed.

The concrete operational stage The hallmark of children's entry into the concrete operational stage is the ability to think using mental operations. Operations are mental representations of both the static and the dynamic aspects of the environment (Siegler, 1998). At this stage, the child can now represent transformations carried out mentally. For example, in the conservation problem, children acquire the ability to mentally represent the transformation that helps them to realize that the quantity of water in the glasses was not changed, only its appearance was altered. An interesting aspect of children's development of the concept of conservation is that, once learned, it is not necessarily applied to all types of conservation problems. The liquid conservation problem we looked at in our example is not the only type of conservation problem. Children must also learn to conserve number, for example, recognizing that rearranging a fixed number of jelly beans does not alter how many jelly beans one has. Similarly, if you take a ball of bread dough and roll it into another shape, the amount of dough does not change. Children presented with different types of conservation problems, number, length, mass, liquid, and area, usually pass the tasks in this order (Brainerd, 1978). You may recognize that this fact does not fit well with Piaget's theory. Remember that Piaget argued that each stage is a qualitatively new level of understanding. The logical competencies which underlie a stage should apply to all tasks that are structurally similar, however, the fact that conservation tasks are acquired in a particular order contradicts this assertion. Evidence has accumulated that children at a given stage do not always show only stage-appropriate levels of performance (Case, 1992b; Lutz & Sternberg, 1999); occasionally, children's familiarity or lack of familiarity with the task materials may lead them to show performance above or below what should be expected of them. Piaget recognized this fact and coined the term **horizontal décalage** to describe this unevenness in the mastery of a concept. The existence of horizontal décalage has been pointed to as a failing of Piaget's theory and evidence that cognitive development may not be as stage-like as Piaget suggested.

Conservation is one of the most important achievements of the concrete operational stage, however, it is not the only accomplishment. During this stage, children develop the mental skills which allow them to understand

classification hierarchies. For example, the child who collects sports cards can now sort them by team, by the players' positions, or in a multitude of other ways. This understanding of classification hierarchies allows children to solve the **class inclusion problem**. In this problem, children are presented with a picture of a bunch of flowers consisting of some white roses, and a larger number of red tulips. Children asked the question 'are there more tulips or more flowers?' correctly answer that there are, indeed, more flowers; that is, they recognize the tulips are a class by themselves as well as members of the larger class of flowers, and therefore, that there must be more flowers. In contrast, preoperational children will routinely fail this question. Concrete operational children also pass **transitive inference** problems. For example, given the information that *John is bigger than Bob, and Bob is bigger than Allan,* they can correctly infer that John is bigger than Allan.

More recent research on these tasks has questioned Piaget's findings. Class inclusion problems have been criticized for the wording of the test question. Donaldson (1978) simplified the question and found that much younger children were able to pass the task. Similarly, Bryant and Trabasso (1971) argued that preoperational children could pass transitive inference tasks when the memory requirements of the task were reduced. These and other findings suggest that, once again, Piaget's estimates of when children can pass these tasks are incorrect. They also call into question his assumptions regarding the discontinuity of cognitive development, suggesting that development may in fact, be more continuous than Piaget believed.

The formal operational stage Whereas the concrete operational child can solve a variety of logical problems such as conservation tasks, transitive inference problems, and class inclusion problems, they still fail to understand logical problems when they are required to go beyond the concrete and to consider the abstract or the hypothetical. Around 11 years of age, children reach the **formal operational stage** which, in Piaget's view, was the endpoint of cognitive development. By the formal operational stage, children become capable of reasoning in propositional, abstract, and hypothetical ways (Inhelder & Piaget, 1958). Formal operational children reason in a specific way, using what has been called **hypothetico-deductive reasoning**. When trying to solve a difficult problem, adolescents start with a general theory of all of the factors which might impact on the outcome of the problem and then try to deduce specific hypotheses in light of these factors. Next, they test their hypotheses and if necessary, revise their theory. This type of reasoning represents the hypothetical and abstract nature of the adolescent's thinking. According to Keating (1990), these characteristics of adolescent thinking, namely hypothesis testing and hypothetical thinking, are what truly distinguish formal operational thought from the previous stage.

Adolescents also think in a propositional manner; that is, they can reason based on the logical properties of a set of statements rather than requiring concrete examples. Osherson and Markman (1975) did a study in which they gave adolescents and younger, concrete-operational children two types of problems. The participants were shown a pile of poker chips of different colours, and were told that they were going to hear statements about the chips and that they should try and state whether these were true or false. In one condition, the experimenter concealed a chip in their hand and said *Either the chip in my hand is green or it is not green* or *The chip in my hand is green and it is not green.* In this case, only adolescents were able to state that the first statement was true and the second false. In another condition, the experimenter made the same type of statements about a different chip but held the chip in plain view. In this case, both groups were able to correctly state whether the statements were true or false. The concrete operational children were able to pass the task when they could match the statement to a concrete property of the chips; when they unable to do this, they failed the tasks. In contrast, adolescents used the logic of the statements themselves; 'and' statements were always incorrect since a chip could not be one colour and another at the same time and 'either–or' statements were always true.

Criticisms focusing on the idea of a formal operational stage concentrate on two main issues: first, whether all individuals reach the formal operational stage and second, whether children might develop the ability to test hypotheses and think abstractly earlier than Piaget suggested. In regard to the first issue, research has shown that, contrary to Piaget's belief that formal operations are universally attained by all normally developing adolescents, a significant number of individuals fail to attain formal operational reasoning. In one study, Keating (1979) showed that between 40 to 60 percent of college students failed Piagetian formal operations tasks. Research has also shown that in many cases, adults do not reason at the level of formal operations (Neimark, 1975). In addition, cross cultural evidence suggests that in many cases, formal operational reasoning is not naturally achieved in other cultures. While the literature on adolescent reasoning clearly supports a distinction in the nature of reasoning exhibited by adolescents and younger children (Keating, 1990; Moshman, 1998), it seems there is considerable variation in the attainment of formal operations, possibly as an effect of schooling practices in literate societies which emphasize logical thinking and problem solving.

To address the question of whether children might show abstract thinking and reasoning abilities earlier than Piaget suggested, we can turn to a study by Ruffman, Perner, Olson, and Doherty (1993). Ruffman et al. showed that 6-year-olds were able to understand the relationship between hypotheses and evidence, recognizing that one needs appropriate evidence to confirm or

TABLE 6.2 Piaget's stages: the preoperational, concrete operational, and formal operational stages

Stage	Age	Description
Preoperational stage	2–7 years	*The growth of representational abilities* • **Egocentrism**: the child at this stage has a tendency to think only from his/her own perspective • **Animistic** thinking: the child attributes lifelike qualities to inanimate objects • Inability to employ mental operations, such as reversibility and conservation tasks • **Centration**: child only focuses on one aspect of a problem
Concrete operations	7–11 years	*The ability to think using mental operations* • **Conversation**: understanding that the physical characteristics of an object or substance or quantity remain the same even their physical appearance may change • **Classification hierarchies**: flexible grouping of objects into classes and subclasses; allows children to solve class inclusion problems • **Transitive inference**: given two statements, such as John is bigger than Bob, and Bob is bigger than Allan, can infer that John is bigger than Allan
Formal operations	11+ years	*Endpoint of cognitive development. Reasoning in propositional, abstract, and hypothetical ways* • **Hypothetico-deductive reasoning**: the ability to start with a general theory of all the factors involved in a problem, the deduction of specific hypotheses considering these factors, and a testing and possible revision of the hypothesis • **Propositional thinking**: Reasoning based on the logical properties of a set of statements rather than requiring concrete examples

reject a hypothesis. They also recognized that hypotheses would constrain a person's predictions about future events. However, children were only able to come to this recognition for very simple sets of variables and relationships. The results from the study by Ruffman et al. (see also Sodian, Zaitchik, & Carey, 1991) suggest that under the appropriate conditions, even quite young children can show some ability to think in an abstract, hypothesis-driven fashion.

Finally, some theorists have advocated the addition of a fifth stage of cognitive development to Piaget's model, a stage which people begin to recognize that thinking occurs in a continuous and increasingly complex manner (Riegel, 1973). Whether cognitive development continues beyond adolescence, however, is still an open question (Moshman, 1998). (See Table 6.2 for an overview of Piaget's stages.)

Criticisms of Piagetian theory

A good theory should be able to integrate a wide array of information and stimulate new research; Piaget's theory does well on both counts. Piaget integrated a great number of diverse facts about children's cognitive development under a coherent theory. Moreover, his theory incorporated development in domains as diverse as *time*, *space*, *number*, and *physics*, showing how development in each of these areas is related to the child's acquisition of an increasingly powerful mental logic. Piagetian theory has also stimulated a great deal of new research, evident in the vast number of studies influenced by his work since the 1960s when his work first became widely known in North America. Importantly, although the bulk of this research has suggested that Piaget's ideas about cognitive development were incorrect on a variety of points, the inspiration for much of this research was his theory. Even though he may have underestimated children's knowledge in many domains, Piaget was responsible for pushing the field of cognitive development forward.

While Piaget's theory has important strengths, it also has been heavily criticized, as shown earlier in this chapter. Piaget's erroneous conclusions regarding children's cognitive ability stem partly from his reliance on verbal interview methods. New developments in methodology have allowed for a better understanding of emerging abilities. Piagetian theory has also been criticized for its adherence to a conception of development as occurring in stages. Development is not necessarily stage-like (Brainerd, 1978). As Siegler (1998) has argued, whether development appears stage-like or more continuous depends in large part on the level of analysis one chooses. If you assess children's competence every few months, then sudden changes in their level of reasoning will appear abrupt and stage-like. If you assess development on a smaller time scale, development may look more continuous.

Piaget's stage theory has also been criticized for its proposed universality. As we have seen, the sequence of stages might not proceed in as orderly a fashion as Piaget suggested. Some stages may not occur across cultures and their development may be heavily dependent on cultural and social factors (Rogoff, 1998). Children's development within stages can also be altered by experience or training.

Other criticisms leveled at Piaget include the complaint that concepts such as *assimilation* and *accommodation* are too vague to be of any use (Brainerd, 1978). Finally, it is possible that development may not occur in an across-the-board or *domain-general* fashion as Piaget suggested. Recent research in cognitive development has increasingly focused on *domain-specific* developments, that is, development within specific domains of knowledge such as biology and physics (Gopnik & Wellman, 1994). The focus of much of this research has been on how the acquisition of knowledge leads to development within a given domain.

Vygotsky's sociocultural theory of cognitive development

In their review of the wide variety of theoretical positions which guide the study of human development, Dixon and Lerner (1999) identified the work of Lev Vygotsky and his emphasis on the cultural contexts in which human development occurs as one of the main forces behind the spread of the family of theories which they label as *contextualist* theories. Like Piaget, Vygotsky was strongly committed to the idea that children were active explorers of their world who test their ideas against reality, seeking to expand their knowledge.

However, unlike Piaget, who viewed children essentially as solitary figures involved in the construction of knowledge, Vygotsky believed that the child's social environment is an active force in their development, working to mould children's growing knowledge in ways that are adaptive to the wider culture in which they grow up. Vygotsky's perspective on development is often referred to as a **sociocultural** view because of his emphasis on the child's culture and the social environment as forces which shape development.

According to Wertsch (1991), there are three main themes which encapsulate Vygotsky's view of cognitive development. First, Vygotsky maintained that the study of development must rely on 'genetic analyses'. This sounds misleading, as like Piaget, Vygotsky used the term *genetic* to refer to the idea of development, *not* to our biological endowment. His idea is that understanding a mental process is only possible through an examination of the origins and the transformations the process undergoes from its immature to its mature form. In other words, the study of development is, in a very real sense, a historical process. Thus, Vygotsky was a strong advocate of the developmental method, focusing on the origins of mental processes and the transformations which they undergo.

Second, as already mentioned, Vygotsky was adamant in his belief that an individual's cognitive development is largely a social process, not an individualistic construction, as Piaget believed. For Vygotsky, cognitive development occurs as a function of the child's interactions with partners who are more highly skilled than the child. These others interact with the child, and through the instruction and assistance they provide to the child, promote cognitive development (Vygotsky, 1935/1978). Vygotsky did believe that the child was equipped with a set of innate abilities but he maintained that these developed only to a limited extent without the intervention of other members of the child's community. Vygotsky referred to the abilities with which the child is naturally endowed, specifically attention, memory, and perception, as the **elementary mental functions**. He contrasted these with the same functions once they are transformed by social interactions with other, more experienced members of the culture. These **higher mental functions** are

the socially transformed products of the child's initial endowment. An important aspect of the higher mental functions is that they are **mediated** processes; they rely on 'mediators' or psychological tools such as language or the number system.

The third major aspect of Vygotsky's theory centres on this notion of mediation. Vygotsky argued that all human cognitive activity, both social and individual, is mediated by the use of symbolic 'tools' such as language, art, numbers, and other culturally derived products. Vygotsky believed that our natural development and our cultural development followed separate lines (Wertsch, 1991); that is to say, the abilities with which we come innately endowed develop to a point without the need for social intervention, following a maturationally based timetable, but then plateau. This halt in the natural line of development comes about because of the child's acquisition of mediators like language. Once children have developed the symbolic capabilities which allow them to interact with other members of their culture, they enter into a dialogue which transforms their innate abilities into the uniquely human, higher mental functions (Vygotsky, 1981).

It is important to note the patterning of development according to Vygotsky's view. Vygotsky stated that: 'Any function in the child's cultural development appears twice, or on two planes. First, it appears on the social plane, and then on the psychological plane' (Vygotsky, 1981: 163). In this statement, Vygotsky argued that development results from processes which occur first *between* people and then occur *within* the individual. Vygotsky referred to this process of functions moving from the interpersonal to the intrapersonal as **internalization**. The development of all higher mental functions occurs in large part, as the result of the internalization. This does not mean that cognitive development is a simple process of copying social processes (Wertsch, 1991). Internalization does involve transformations of social processes by the individual; however, Vygotsky did advocate that our cognition is strongly grounded in social processes.

The zone of proximal development

Vygotsky (1978) believed that the interactions between parents and children which led to intellectual development took place in a specific way. He proposed the concept of the **zone of proximal development** (**ZPD**) as a way of illustrating how social interactions between experienced members of the culture and less experienced children led to development. He defined the zone of proximal development as the difference between the child's 'actual developmental level as determined by independent problem solving' and their 'potential development as determined through problem solving under adult guidance or in collaboration with more capable peers' (Vygotsky, 1978: 86).

There are two aspects of the concept which are important to note (Cole, 1985). First, the zone of proximal development represents a specific way in which more capable members of the culture assist the child's development. This is achieved by working with the child at a level slightly beyond the child's own capabilities. We will examine this aspect further later. Second, the zone of proximal development highlights Vygotsky's concern with how intellectual functioning is measured. Vygotsky felt it was critical to measure the child's *potential* for learning under adult guidance; such a measure of intelligence has a greater utility according to Vygotsky than a simple assessment of what the child is capable of doing alone. Given his belief in the study of developmental processes rather than endpoints, Vygotsky's emphasis on the child's potential as the state we should be concerned with in assessment is extremely appealing.

The zone of proximal development has had a great influence on the study of cognitive development. One way in which it has had an influence is on how developmentalists think about the quality of instruction children receive from others. Vygotsky did not specify how adults and children worked within the zone of proximal development, but later researchers, looking more carefully at the processes involved came up with the term **scaffolding** (Bruner, 1983; Wood, Bruner, & Ross, 1976) to describe the processes involved. Scaffolding is an interactive process in which adults adjust both the amount and the type of support they offer to the child, leading to the eventual mastery of the skill being taught. When adults provide effective scaffolding for a child, they initially try to encourage the child to operate at the limit of their ability. If the child does not respond, the adult will use more specific behaviours to direct the child and, in addition, they may vary the type of instruction offered. As the child begins to experience success, the adult intervenes in more indirect ways, reducing their level of instruction and encouraging the child to move forward. The key to effective scaffolding is a sensitivity to the child's level of development (Rogoff, 1998; Wood & Middleton, 1975). Research has shown that when mothers are more effective at scaffolding their children's behaviours in the context of a problem solving task, the child is more likely to act successfully on their own in a similar task (Berk & Spuhl, 1995).

Language and play

A key question we need to ask is whether or not there is any evidence for Vygotsky's idea that development proceeds from the social plane to the individual? One phenomenon which Vygotsky cited as evidence for this progression was children's speech to themselves. You may have noticed that preschool children often talk to themselves while performing problem solving

tasks or while carrying out everyday activities. For example, while playing with toy blocks young children can often be heard uttering things such as '*Now I need a blue one*' or '*That doesn't go here*'. Jean Piaget noticed this tendency as well. He referred to this as **egocentric speech**, believing that because of the preschool child's inability to think from another's perspective, their communications were often profoundly egocentric, that is, not adapted to another's viewpoint. Vygotsky took exception to Piaget's classification of children's speech as egocentric. In contrast to Piaget, Vygotsky (1934/1986) believed children's speech to themselves is a powerful means of regulating their own behaviour. Language gives children the means to reflect on their own behaviour, to organize behaviour, and to control their behaviour. Children's speech to themselves reflects the fact that their thought is organized in the form of dialogues with others and because thought is dialogic, the language which supports it gets expressed. As children become more competent with cognitive tasks, these dialogues become internalized and their speech to themselves declines in frequency. A good deal of research has shown that Vygotsky's view of children's speech to themselves is a better description of children's behaviour than is Piaget's, and have adopted the term **private speech** (in contrast to Piaget's term egocentric speech) to describe this behaviour (e.g., Berk, 1992). Furthermore, in accord with Vygotsky's view, children who use private speech show greater improvement on problem solving tasks than their peers who do not use (or use less) private speech.

Like Piaget, Vygotsky (1978) also took notice of young children's tendency to engage in pretend play, and he pointed to an interesting fact about it. Vygotsky noted that children's pretend play tends to occur at a level beyond their stage in life; that is, in their pretense, children take on roles such as *parent* or *doctor* rather than roles that are appropriate to children. Through pretend play, children place themselves in a zone of proximal development, where they play at a level which is in advance of their real capabilities. Pretend play has the ability to stimulate development in a variety of ways. One way has to do with the child's use of their imaginations. In pretend play, children learn that the objects they use can be separated from their normal referents, and that they can stand for other things. Thus, the child can play with the banana as if it were a telephone. In addition, pretend play tends to be based on rules. The child who pretends to be a baby has to follow the rules and go to sleep when their pretend mummy tells them to, and the child who pretends to be a daddy may have to pretend to cut the lawn. In other words, children's play is constrained by the rules which guide behaviour in these roles, and, because of this, they learn about the social norms that are expected of people. Vygotsky believed that pretend play was an important context in which children learned about the social world.

The implications of Vygotsky's theory for education

Vygotsky's theory has had a major impact on education in recent years, largely because of his stress on the importance of social interactions with more experienced others as a force which drives learning. Vygotsky's belief was not simply that education was a process of refining cognitive structures which the child has already acquired; instead, he maintained that education was a fundamental aspect of human development. Social interactions with more experienced others are essential to our education.

Vygotsky's theory has much to say about how education might best take place. Peer collaboration is a key concept in the Vygotskian approach to education. One educational device that has been developed on the basis of Vygotsky's theory is called **reciprocal teaching**. Reciprocal teaching is a method of using peers to foster dialogues about a subject matter such that they provide a level which is beyond the individual child's capability but within their zone of proximal development (Brown & Palinscar, 1982; Palinscar & Brown, 1984). The method was designed to improve the reading ability of children who were designated as having academic difficulties but it has been extended into other subject areas, such as science. The reciprocal teaching method involves the student in a group with several other students and a teacher. The aim of the group is to engage in collaborative learning, that is, to make certain that the entire group works through and learns a topic. Within the group, students take turns at leading discussions on a particular text. The leader of the group discussion is responsible for ensuring that all the students take part in all phases of the discussion. There are four activities that are required of students within the group: questioning, summarizing, clarifying, and predicting. In a reciprocal teaching group, the leader of a discussion begins the learning process by asking questions about the content of the text. In this phase, group members answer questions, elaborate on others' statements, try to resolve disagreements (by rereading if necessary) and raise questions of their own. This is followed up by the leader's summary of the text and a period of clarification where group members who have trouble grasping certain ideas try to work through these with the group. Finally, the group is asked to use their understanding to predict future content of the text. The idea of reciprocal teaching is to make the processes which a skilled reader engages in automatically more *explicit* so that group members who have problems with these skills can internalize them. As you can see, the practices engaged in by students in reciprocal teaching are very consistent with Vygotsky's theory.

Another way in which Vygotsky's theory is employed in the classroom is through **cooperative learning**. This is a technique in which the child's learning environment is structured into small groups of peers who work together toward a common learning goal. Unlike reciprocal teaching, a teacher is not used to guide each group. Instead, groups are formed from

combinations of more and less knowledgeable peers. Cooperative learning environments work best when children truly adopt and share common goals (Forman & McPhail, 1993) and when the group consists of children who are truly accomplished at the particular task and who can provide expert instruction to others who are less skilled (Azmitia, 1988; Rogoff, 1998).

Criticisms of Vygotsky's theory

Vygotsky's theory has proven very influential in recent years and has inspired a great deal of research and speculation regarding the role of culture and social interaction in human development (Rogoff, 1998). However, the relatively recent entry of Vygotsky's theory into the study of human development means that the theory has not yet received the same level of critical analysis that more established theories such as Piaget's have received (Miller, 1993).

One aspect of Vygotsky's work which has been heavily criticised is his almost exclusive focus on the cultural aspects of development. Recall that Vygotsky distinguished between the *natural* line of development and the *cultural* line, however, his theory tells us almost nothing about the natural line of development. Consequently, it is not possible to understand within the confines of Vygotskian theory how exactly the elementary processes such as attention and memory contribute to the development of symbolically mediated forms of cognition (Wertsch & Tulviste, 1992). Importantly, children's cognitive abilities are used as indicators of the kinds of social experiences which will be made available to them. Vygotsky's theory has little to say about how children's developmental level serves to constrain or enhance their opportunities for participation in various contexts. Other issues which are raised as challenges for Vygotskian and other contextualist theories include: the examination of how people determine the goals of their collaborative efforts and the means by which these are carried out; how children and adults collaborate outside the context of experimental settings; the dynamics of groups larger than two persons; and the nature of interactions in cultures other than middle-class, North American, and European groups (Rogoff, 1998). Rogoff has pointed out that, given the typical emphasis in developmental research on the *individual* as the unit of study, it is not surprising that we have little information on some of these questions. The current interest in Vygotskian and other sociocultural theories suggests it is only a matter of time before these and other critical issues begin to be addressed.

Information processing theories

The **information processing approach** to cognitive development is based on an analogy between the digital computer and the human mind. Most

information processing theorists share the view that the mind is a system which manipulates symbols according to a set of rules. Like computers, our minds encode information received from the environment, cast it into a symbolic form which the mind can process, and through a variety of operations, processes this information to produce useful output such as the solution to a problem. There are other parallels between human cognition and computers that have been explored by information processing theorists. Like computers, we also have finite resources such as memory which place limits on our cognitive performance. As well, just as computers 'develop' in terms of the sophistication of their hardware, so does the human brain develop, leading to the growth of more powerful thought processes. However, as Klahr and MacWhinney (1998) caution, information processing theorists do not literally believe that the mind is a computer. Rather, they see the computer as a tool for testing models of cognitive development. In essence, the goal is to test whether a theory of intelligent behaviour can be accounted for by a computational system, whether the computations are run in a brain or on a computer.

While there are a large number of information processing theories, all approaches share three basic assumptions (Siegler, 1998). The first belief is that *thinking is information processing*; that is, any thought process such as remembering or perceiving involves the processing of information. Second, information processing theories emphasize the need to study the *change mechanisms* that move development from one state to the next. Third, development within information processing systems is driven by *self-modification*; that is, earlier knowledge and strategies can modify thinking and thus, lead to higher levels of development.

The information processing system

According to Siegler (1998), information processing theories focus on the organization of the information processing system, or what he calls the *structural characteristics*, and the *processes* that provide the means for cognition to adapt to the changing demands of the environment. We examine these two aspects of the information processing system in turn.

The structural characteristics of the information processing system are believed to be universal in that all children share the same basic organization of cognitive structures. Springing from the work of cognitive psychologists (e.g., Atkinson & Shiffrin, 1968; 1971), most theories of information processing are based on a three-part model (known as the **store model**) which consists of a **sensory register**, **working memory**, and **long-term memory**. In this store model, information is believed to flow into the cognitive system through the sensory register. The sensory register is a memory

store which allows us to briefly store large amounts of sensory information (e.g., visual images and sounds) for a very short duration, somewhere around one second (Sperling, 1960). If you look closely at something, close your eyes, and monitor your experience you will notice that a visual image of the scene will last for a brief time. From the sensory register, information flows into working memory (also referred to as short-term memory).

Working memory is the area of the system where thinking occurs. That is, working memory allows us a space from which to operate on incoming information, combining it with long-term memory, or transforming it in various ways. A critical point regarding working memory is that it is a limited resource. First, working memory is of limited *capacity*; that is, we can only store so much information in working memory at one time. Estimates of working memory capacity suggest that it can hold approximately 7 units of information (Miller, 1956). Second, information can only be held in working memory for a brief period, somewhere in the order of 15 to 30 seconds (Siegler, 1998). Thus, working memory provides a bottleneck in the system because of this limited capacity. Incoming information pushes information out of working memory such that it is either forgotten or it is moved into long-term memory. An important aspect of working memory is that its capacity can be increased through the application of strategies such as **chunking**, where information held in working memory is organized into more meaningful units. For example, instead of treating the first three digits of a phone number as three separate units of information, you can chunk them into a single unit, remembering '388' instead of '3', '8', and '8'. Chunking allows us to increase our working memory capacity, and, thus, to form more complex mental representations.

Information from working memory can move into long-term memory. Long-term memory is the part of the cognitive system that contains our permanent knowledge base. It is a storehouse of information which seems to have no limit, in terms of either its capacity or in how long information can reside here. Many theorists believe that long-term memory is organized as an *associative network*, in that to retrieve information we need to have cues that allow us to find the stored information (Atkinson & Shiffrin, 1968; Broadbent, 1984). The more associations we form between an item and cues which help us retrieve it, the more likely it is we will remember the item, that is, bring it from long-term to working memory.

As noted earlier, there are a number of processes which may operate on information held in the three memory stores. Unlike the architecture of the information processing system, these processes show considerable development over time; that is, children gain greater expertise with these strategies leading to the more efficient handling of information within the cognitive system. One important process is **encoding**. Given the finite capacity of our

sensory register and working memory, we are limited in the amount of information that we can manage to transform into mental representations. Encoding is the process by which we pick out the important features of an object or event so that we can form a representation. Efficient encoding processes allow us to quickly pick out the relevant features that are important to our thinking. In contrast, inefficient encoding processes can lead to the loss of information, producing limitations in the usefulness of the representations children form. Another critical process is **automatization**. Cognitive psychologists (Shiffrin & Schneider, 1977) distinguish between *controlled* processes, that is, processes which require conscious attention, and *automatic processes*, processes which require little or no conscious attention.

The more controlled a process is, the more working memory capacity it requires. Thus, the processes that lead to the automatization of some task are generally beneficial in that they free up mental resources that can be allocated in other ways. Consider a child learning to solve simple arithmetic problems such as 'What is 5 + 3?' At first the child may count off five fingers and then count off a further three fingers, and then count up the total number of fingers which are raised (Siegler, 1998). However, with practise, children begin to memorize the solutions to these simple problems. That is, they have automatized the answer and can simply recall the product of the addition without counting it out. The automatization of a skill leads to increases in the speed of the child's ability to execute it as well as leaving more free working memory capacity so that the child can monitor their cognitive performance and, perhaps, learn to further improve their abilities through the application of strategies.

A neo-Piagetian theory of cognitive development

One of the many information processing theories of cognitive development is that of Robbie Case (1985; 1992b). Case's theory of cognitive development is similar to Piaget's in that it postulated broad, qualitative changes in cognitive development; Case, however, differs from Piaget in that he believes that shifts in cognitive development result from increases in the child's information processing capacity (i.e., working memory). In his theory, Case refers to the growth of information processing capacity as **m-space** and argues that these increases in capacity represent the child's ability to use their limited capacity more efficiently. Case attributes the growth of information processing capacity as stemming from three processes. First, the maturation of the brain leads to increases in information processing capacity through increases in the speed with which mental operations can be carried out. A neural process called myelinization speeds up the transmission of electrical impulses through the brain and thus, increases speed. In turn, speed increases capacity by utilizing

working memory more efficiently. Second, the development of cognitive strategies also frees up capacity, speeding up the process of automatization. Finally, automatization of knowledge and schemes leads to the development of *central conceptual structures*. These are networks of concepts and relations between concepts which allow the child to think about some situations in more advanced ways. Case and Griffin (1990) argued that because central conceptual structures lead to the development of more efficient means of thinking about situations, they too free up information processing capacity.

One of the great strengths of Case's theory is its ability to account for the transition from one stage of thought to another. Case argues that the increases in m-space lead to the child moving from one stage to the next; that is, when the child acquires enough m-space to represent a situation in a more complex way, they have progressed to a new level of thinking. In support of this idea, Case has conducted a great deal of research which shows strong correlations between measures of m-space and cognitive performance; the greater one's m-space, the higher is the level of cognitive development. Case's theory represents an important step beyond Piaget, combining concepts from information processing theory with Piaget's ideas, providing us with a more comprehensive and testable account of cognitive development.

SUMMARY

Our survey of the theories of Piaget, Vygotsky and the information processing tradition captures some of the differences in opinion which exist about how to tackle the study of children's cognitive development. Each theory emphasizes different factors as being important to an understanding of cognition. The Piagetian tradition focuses on the nature of children's interactions with their physical environment, whereas Vygotskian theory stresses that social interactions between children and more skilled members of their culture are critical to cognitive development. In contrast to both of these positions, the information processing theorists emphasize the importance of studying the mechanisms which lead to developmental change. As was noted at the outset, covering the whole field of cognition is beyond the scope of this book, but armed with a knowledge of these theories, you should be in a position to understand much of the research in this field.

Glossary

Accommodation is the process of adjusting old schemes to better fit with the demands of the environment (the complement of assimilation).

Adaptation involves the creation of cognitive structures or schemes through our interactions with the environment, allowing us to adjust to the demands posed by the environment. An important aspect of the higher mental functions is that they are **mediated** processes, relying on systems such as language or the numerical system.

Animistic thinking refers to the tendency to attribute life-like qualities to inanimate objects such as plants or rocks.

A-not-B task in which infants search for hidden objects, first at one location (the A trials) and then later, at a second location (the B trials). Used by Piaget to test for object permanence.

Assimilation refers to the process of integrating the environment into one's current psychological structures, using current schemes to interpret new knowledge (the complement of accommodation).

Automatization is the processes by which behaviours that require conscious, controlled attention are transformed so that they require little or no conscious attention.

Centration refers to the quality of a child's thinking which leads them to focus on only one characteristic or dimension of a task or problem.

Chunking is a process whereby the information held in working memory is organized into a smaller number of more meaningful units.

Class inclusion problem is a problem designed by Piaget to test children's understanding of classification hierarchies.

Conservation task Piaget's task which tests children's understanding that the physical characteristics of an object, substance, or quantity remain the same even though their physical appearance may change.

Cooperative learning is a technique in which the child's learning environment is structured into small groups of peers who work together toward a common learning goal.

Egocentric speech is communication that is not adapted to another's viewpoint.

Egocentrism refers to the child's tendency to think only from their own perspective, failing to consider other possible viewpoints.

Elementary mental functions in Vygotsky's view, the abilities with which the child is naturally endowed, such as attention, memory, and perception.

Encoding is the process by which we pick out the important features of an object or event so that we can form a mental representation.

Equilibration is Piaget's term for the striving of the cognitive system to maintain a state of equilibrium.

Explicit knowledge is knowledge which is accessible to consciousness.

Formal operational stage the stage of cognitive development where adolescents become capable of reasoning in propositional, abstract, and hypothetical ways. In Piaget's view, the endpoint of cognitive development.

Higher mental functions in Vygotsky's view, cognitive functions that have been transformed by social interactions with other, more experienced members of the culture.

Horizontal décalage is used to describe the unevenness in children's mastery of the different forms of a concept such as conservation.

Hypothetico-deductive reasoning is a form of reasoning where a child starts with a general theory of all of the factors which might impact on the outcome of a problem and then tries to deduce specific hypotheses in light of these factors. Next, they test their hypotheses and if necessary, revise their theory.

Implicit knowledge is knowledge which is not accessible to consciousness but which still plays a role in guiding behaviour.

Information processing approach is an approach to the study of cognitive development which focuses on how information is encoded from the environment, cast into a symbolic form which the mind can process, and processed through a variety of mental operations to create useful output, such as the solution to a problem.

Internalization refers to Vygotsky's belief that processes initially carried out at the social level can be internalized by the child and carried out within the individual. For example, dialogues carried out between a parent and child become internalized and can be used by the child to guide their own thoughts and actions.

Long-term memory is the part of the cognitive system that contains our permanent knowledge base. It is a storehouse of information which seems to have no limit, in terms of either its capacity or in how long information can reside here.

m-space refers to the child's capacity to hold information actively in mind. m-space is believed to increase with development through to adolescence.

Object permanence refers to the concept that objects continue to exist independently of our ability to perceive or to act on them.

Operations refer to procedures that can be carried out on some mental content.

Organization refers to the individual's tendency to organize their cognitive structures or schemes into efficient systems.

Pretend play is play where children act out imaginary activities and use real objects to stand for imagined objects.

Primary circular reactions Piaget's term for simple motor habits seen in infants such as thumb sucking that can be repeated and which are pleasurable.

Private speech refers to speech used to guide the child's behaviour. Private speech is more likely to occur when children are faced with a difficult task and becomes less frequent as children get older.

Reciprocal teaching is a method of using small groups of peers to create dialogues about a subject matter, providing a level of instruction which is beyond the individual child's capability but within their zone of proximal development. It emphasizes four cognitive processes: predicting, questioning, summarizing, and clarifying.

Reversibility is the idea that a mental operation can be reversed by carrying out a second operation which is the inverse of the first. For example, the addition of two numbers can be reversed by subtracting an amout equal to that added to the initial quantity.

Scaffolding is an interactive process in which adults adjust both the amount and the type of support they offer to the child, leading to the eventual mastery of the skill being taught.

Schemes is the term used by Piaget to refer to an interrelated set of actions, memories, thoughts, or strategies which are employed to predict and understand the environment.

Secondary circular reactions are behaviours focused on the environment which produce interesting reactions which the infant attempts to maintain through repetition.

Sensorimotor stage refers to the first two years of an infant's life during which the infant moves from responding to the environment in a simplistic, reflexive manner, to being able to think in symbolic forms, and in a goal-directed manner.

Sensory register is a memory store which allows us to briefly store large amounts of sensory information for a very short duration.

Sociocultural theory refers to Vygotsky's perspective on development which places a strong emphasis on the child's culture and the social environment as forces which shape development.

Stage a stage of development is a period in which the child's cognitive structures are qualitatively similar.

Store model a model of the flow of information through the cognitive system which posits a variety of information stores including the sensory register, short-term memory, and long-term memory.

Transitive inference problems are a class of problems where the child must make an inference based on premise information contained in the problem and the concept of transitivity.

Working memory is a mental space from which we operate on incoming information, combining it with long-term memory or transforming it in various ways.

Zone of proximal development is the difference between the child's independently determined developmental level and their potential level of development determined when problem solving under adult guidance, or in collaboration with more capable peers.