CHAPTER 2
Theories in Developmental Psychology

Introduction

'If you want to get ahead, get a theory.'

This quotation is actually the title of a paper written by Annette Karmiloff-Smith and Barbel Inhelder (1975). Rather than instructing psychologists on how to conduct scientific investigations, this paper actually addresses how young children develop theories in order to take an active role in shaping their own learning until they settle on the best one (in this case the children try several different approaches to solving how to balance a set of scales). But the point is well taken with respect to both children's own development and the process of undertaking research into children's development. Rather than passively observing and measuring the world around us (we might be waiting for ever for something interesting to occur), developmental scientists propose theories that can be tested in order to make the progress in understanding of development quicker.

THE ROLE OF THEORIES IN DEVELOPMENTAL PSYCHOLOGY

As we explained in Chapter 1, developmental psychologists undertake their work in order to answer two key questions: (i) to describe developmental change, and (ii) to explain developmental change. The job of theories of developmental psychology is to advance coherent and plausible solutions to these questions about how and why developmental change occurs. Such theories can then be taken out into the world or into the research lab to investigate their validity. As is the practice in other branches of psychology, and indeed other scientific disciplines, developmental scientists draw out predictions from theories and then empirically test those predictions in experiments or observations in order to determine whether or not the theory is correct. If the theory stands up well to this empirical testing, then further predictions are drawn out and tested. If the empirical test indicates that the theory is incorrect, then the theory is adapted or rejected altogether. Thus, developmental theories do two important things. First, they help organize and integrate existing information into coherent, interesting and plausible accounts of how children develop. Second, they generate testable hypotheses or predictions about children's behaviour.

Because theories stand or fall on the basis of scientific (empirical) findings, there is a sense in which they can be construed as ephemeral (short-lived) things, which are rejected and replaced as soon as research shows them to be incorrect. There is some truth to this, as developmental scientists are quick to place their bets on the view that is best supported by current empirical data, and as empirical data are accumulated, this frequently changes our understanding of development. However, in some situations alternative theories can be more long-lasting or co-exist. Theories which have a longer relevance often have a broader scope that attempts to account for or describe more than one developmental phenomenon (e.g., if it explains aspects of both language development and mathematical development). Piaget's constructionist argument is a good example of this. As we shall describe later, Piaget attempted to explain a great many aspects of cognitive development as being due to a process of active construction by the child. Because such broader-scope theories do not stand or fall on the basis of a single empirical observation they outlast findings that show just one element to be incorrect.

There are, however, reasons other than scope for why some theories outlast others. One of these reasons is the novelty of the explanatory approach that they offer. Across the history of developmental psychology there have been several novel theoretical contributions in which a theorist has offered a new way of describing or explaining developmental change, which had not been considered before. An example of this might be the relatively recent emergence of connectionist and dynamic systems models of development. Before the emergence of these explanatory models, stage-changes in development (of the sort described by Piaget) were explained in terms of qualitative changes in knowledge or thought (e.g., sudden insights). The mildly troubling question concerns where these qualitative shifts come from.

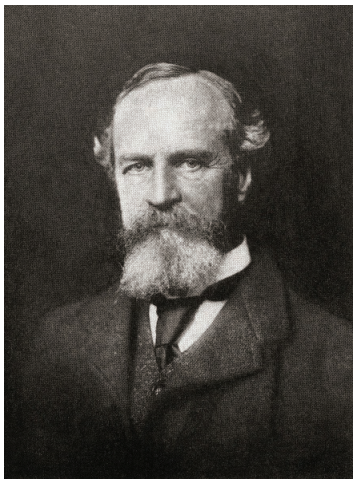
Piaget and others, of course, had answers to this question. However, the emergence of dynamic systems and connectionist models demonstrated for the first time that stage-wise shifts can come about due to the interaction of several small-scale quantitative developments in learning and other factors (e.g., learning interacting with the physical sizes of the limbs). Because these new advances in conceptualizing the how and why of developmental change are novel and deserve to be considered among the alternatives when seeking to explain any given development, they continue to be referred to as important and influential theories.

In addition, it is not uncommon for contrasting developmental theories to co-exist. For instance, we have invoked Theory of Mind or executive function explanations to account for children's failures to understand others' false beliefs (a false belief is a belief that someone thinks something that is incorrect, perhaps because they lack some knowledge information that the child has). Contrasting theories may provide different accounts for the same observation or phenomenon, and in such cases researchers will often develop experiments to test out which of the two competing explanations is more adequate. Often, however, contrasting theories may co-exist because they account for different elements of a broader phenomenon or aspect of behaviour. Co-existing theories can, eventually, be compared and evaluated once more information is gathered or known, or once researchers can agree on specifics or have agreed and reliable observations.

For the next part of this chapter we will describe the key aspects of some of the most influential theoretical approaches to explaining human development. Because theories themselves develop out of the current state of knowledge in which they exist, we have ordered them in this chapter according to a rough chronology of the influence they have had on the field of developmental psychology over the past 120 years.

ORIGINS OF THOUGHT ABOUT HUMAN DEVELOPMENT

Philosophers had been considering questions about psychological development well before the origins of psychology as a scientific field of study. An important question among philosophers in the seventeenth century concerned whether humans require experience of the world in order to perceive and understand it. John Locke (1632–1704), in a similar vein to other 'British empiricist' philosophers like Berkeley and Hume, argued that infants are born into the world *tabula rasa* – that is, as a 'blank slate'. This metaphor is meant to suggest that because they have been unable to learn from the outside world, newborn infants understand nothing of it when they emerge from their mother's uterus. On the other side of the argument were 'rationalist' philosophers (including Leibniz and Descartes), who argued that the mind imposes some kind of order on the environment in order to be able to comprehend it. This argument closely resembles the tension between 'nativist' accounts of development, which emphasize nature and inheritance, and more 'empiricist' positions, which emphasize the role of nurture and environment in development.



Important foundational figure in developmental psychology: William James.
© Universal History Archive/Getty Images

At the end of the nineteenth century, when psychology became established as a scientific discipline in its own right, the question of nature and nurture was similarly on the minds of the early psychologists. William James (1890) famously took a rather empiricist position on the origins of perceptual abilities in babies (see Chapter 6), stating that newborn infants perceive only 'a blooming buzzing confusion'. This 'blank slate' assumption was later echoed in the behaviourist school, which we will discuss next. As we shall see, the principal opponents to this empiricist view were the maturationists who, drawing much on Charles Darwin's ideas about human evolution and natural selection (see Chapter 1), suggested that development is shaped more by a genetic blueprint than the environment.

BEHAVIOURISM AND MATURATIONISM IN THE EARLY TWENTIETH CENTURY

Behaviourism

In Chapter 1, we described how a major discussion in developmental psychology concerns whether development is characterized as continuous (gradual) or discontinuous (sudden). Behaviourism argued that development was characterized by continuous and gradual changes in behaviour.

behaviourism A school of psychology prominent in the early twentieth century, which emphasized the role of learning in human behaviour and attempted to describe behaviour in such terms.

classical conditioning A type of learning in which two stimuli are repeatedly presented together until individuals learn to respond to the unfamiliar stimulus in the same way they respond to the familiar stimulus.

The behaviourist approach to development is exemplified in the work of John B. Watson, Edward Lee Thorndike, Ivan Pavlov and B.F. Skinner. **Behaviourism** emerged as an important school of thought in psychology in the early twentieth century. Behaviourists focused on the learning of behaviours in animals and humans. As such their approach is not specifically a developmental one. In fact, perhaps the most well-cited behaviourists spent more of their time working with mature animals (rats, dogs, pigeons) than with human children. Nonetheless, the behaviourists (John Watson is a particularly prominent example) argued that the principles of learning which they observed in mature adults (animal or human) also play a fundamental role in development. The key tenet of their position is that changes in behaviour are driven by experience, and that these changes in behaviour happen gradually and continuously (rather than in shifts or stages, such as when we have sudden insight into a problem). The behaviourist position on development is perhaps best summed up by the following quote from John Watson:

> *Give me a dozen healthy infants . . . and I'll guarantee to take any one at random and train him to become any type of specialist I might select – doctor, lawyer, artist . . . even beggar man and thief, regardless of his talents, penchants, and race of his ancestors. (Watson, 1930, p. 104)*

But what were these learning principles that the behaviourists considered so important? The two key forms of learning they advocated were classical conditioning and operant conditioning. **Classical conditioning** was first discovered by Pavlov, in the early twentieth century, while he was investigating the physiology of digestion in dogs. He was presenting food to dogs and measured their salivary response, when he made an accidental but important discovery. He noticed that, with repeated testing, the dogs began to salivate before the food was presented, such as when they heard the footsteps of the approaching experimenter. Pavlov concluded from this and further investigations that the dog was able to learn an association between two stimuli (in this case food and arriving footsteps) and behave accordingly.

Rather infamously, Watson and Rayner (1920) used Pavlov's concept of classical conditioning to examine whether other behaviours, and even emotions such as fear, could be conditioned in children. They worked with an 11-month-old infant named Albert. Watson and Rayner presented Albert with a white rat to which he displayed no sign of fear. Later, in the learning phase of their experiment at the same time as presenting the rat to Albert they hit a steel bar with a hammer, making a loud clang. The noise of course scared Albert and made him cry. After several of these learning episodes even the sight of the rat on its own made Albert cry.

Unfortunately for Watson and Rayner, in addition to their having conducted a particularly unethical experiment, their results were not very conclusive. After several attempts to condition fear in Albert to several animals (including the rat again, but also a rabbit and a dog), Albert showed little reaction to all of these animals in a different room (Harris, 1979). Records do not tell us whether Albert went on to experience phobias in later life.

Watson and Rayner examine how Little Albert reacts to a furry mask.
Source: Courtesy of Professor Benjamin Harris

Edward Thorndike and B.F. Skinner examined another form of learning, which is most commonly referred to as **operant conditioning** (you will sometimes hear it referred to as instrumental conditioning). Operant conditioning is a type of learning in which new behaviours are learned in response to a specific stimulus. Importantly, operant conditioning is controlled by a manipulation of the consequences of behaviour. Thorndike and Skinner found that by providing a reward for a particular behaviour in response to a stimulus, they could encourage that 'stimulus-response' pairing later. It was first studied in animals (e.g., cats, rats and pigeons), but was later applied to children's behaviour. There are different kinds of reward. Positive reinforcement could be a food pellet, or something else with positive connotation for the participant. On the other hand, punishment or withdrawal of privileges can decrease the chance that the same behaviour will be produced in a given context.

As we shall describe in Chapter 10 it has been possible to demonstrate classical conditioning in human infants in a much more humane way than that which Watson and Rayner attempted.

operant conditioning
A type of learning that depends on the consequences of behaviour; rewards increase the likelihood that a behaviour will recur, whereas punishment decreases that likelihood.

maturational approach
An early approach to explaining development in terms of maturational timetables, predetermined by genetic inheritance.

Inspired by their success with animals, Skinner and Thorndike went on to advocate the use of operant conditioning to guide the way children develop. Indeed Skinner predicted positive changes in society if such conditioning was introduced in a widespread way. Behaviourism continues to have an important influence on modern developmental psychology. An instance of operant conditioning being used to change the behaviour of children is provided by Patterson and his colleagues (Patterson, 1982; Patterson & Capaldi, 1991). They showed that punishment of children's aggressive behaviour by 'time out' – a brief period of isolation away from other family members – can help diminish aggressive behaviour. Operant conditioning has been incorporated into many applied programmes to help teachers and parents change children's behaviour, including hyperactivity (restlessness, inattention, impulsivity) and aggression.

Maturational theory

The maturationists mapped out the developmental trajectories of growth and of developing motor skills (see Chapters 4 and 7).

At the beginning of the twentieth century, the major opposition to the behaviourist school of thought concerning children's development had come to be known as the **maturational approach**. 'Maturationists' argued that, far from being entirely shaped by experience (as suggested by John Watson), the emergence of infants' and children's abilities are to a large extent determined by our genetic inheritance. Inspired by Darwin, Arnold Gessell and Myrtle McGraw (both key figures in the maturational approach) they examined the directions (or trajectories) of development of certain skills. Observing that skills appear to unfold developmentally in particular orders, they argued that these 'biological timetables' of development were set out in advance by the genes of our species.

As we will see in Chapters 4 and 7, the body, and our ability to undertake certain motor skills, develops in certain directions or trajectories (e.g., an ability to control the hands develops after an ability to control the neck and torso). Gessell (Gessell & Ames, 1940) argued that this was due to a maturational timetable inherited in our genetic code. Further evidence for this important role of inheritance was supplied by an influential study of two identical twins (Jimmy and Johnny) by McGraw (1935). McGraw observed that, even though one of the twins was given additional motor stimulation, Jimmy and Johnny's motor development nonetheless remained closely linked. Maturational explanations have been applied throughout developmental psychology. For instance, maturational theories have been very influential in explaining the emergence of children of different temperaments (see Chapter 7).

Arnold Gessell – a maturational theorist.
© Herbert Gehr/Getty Images

Even though the maturationists and the behaviourists represent quite different sides of the nature–nurture argument, it is important to acknowledge that they, like modern developmental scientists, adopted variations on a moderate position, acknowledging that nature and nurture have a role, but varying as to how much importance they placed on those relative roles. As we shall see, perhaps the most important advance on this position was that of Piaget, who next attempted to understand exactly how nature and nurture interact. However, before moving on to Piaget we will discuss some important theoretical approaches in developmental psychology that were being formulated at the same time as the maturational and behaviourist positions.

PSYCHODYNAMICS AND ETHOLOGY

The psychodynamic approach

In the early 1900s, Sigmund Freud introduced his theory of **psychodynamics**. Freud's theory of psychodynamics is best known in the context of treatment of psychological disorders. Freud was particularly concerned with attempting to solve mental turmoils, and psychoanalysis – a particular tradition in the study and treatment of psychological disorders – emerged from his work. Freud's psychodynamic theory, rather than addressing particular behaviours and abilities, attempts to discern and describe the more internal motivations and personalities of individual people. Importantly for us, he took the view that adults' motivations and personalities were largely formed through the experiences of infancy and childhood. This theory is very complex and covers many aspects of psychological functioning. Here we concentrate on the parts of this theory that have influenced developmental psychology.

psychodynamic theory In this view of development, which is derived from Freudian theory, development occurs in discrete stages and is determined largely by biologically based drives shaped by encounters with the environment and through the interaction of the personality's three components: the id, ego and superego.

id In Freudian theory, the person's instinctual drives; the first component of the personality to evolve, the id operates on the basis of the *pleasure principle*.

ego In Freudian theory, the rational, controlling component of the personality, which tries to satisfy needs through appropriate, socially acceptable behaviours.

superego In Freudian theory, the personality component that is the repository of the child's internalization of parental or societal values, morals and roles.

For Freud, the developing personality consists of three interrelated parts: the id, the ego and the superego. The roles of these three components of personality change across development as the infant, who is largely under the control of the **id**, or instinctual drives, gradually becomes more controlled by the ego. The **ego** is the rational and reality-bound aspect, and attempts to gratify needs through socially appropriate behaviour. With further development, the third component of personality, the **superego**, emerges when the child *internalizes* – that is, accepts and absorbs – parental or societal morals, values and roles, and develops a *conscience*, or the ability to apply moral values to her own acts.

To Freud, personality development – that is, changes in the organization and interaction of the id, ego and superego – involves five stages (see Table 2-1). In the first, the *oral* stage, the young infant is preoccupied with pleasurable activities such as eating, sucking and biting. In the second to third year, the child enters the *anal* stage and learns to postpone personal gratification, such as the pleasure of expelling faeces, as he is trained to use the toilet. Following the anal stage, the *phallic* stage begins, and curiosity about sexual anatomy and sexuality appears. Freud saw this stage as critical to the formation of gender identity. During the *latency* period, from about 6 years of age to puberty, sexual drives are temporarily submerged and children avoid relationships with peers of the other gender. In the last stage, the *genital* period, sexual desires emerge and are directed towards peers, a topic we return to in Chapter 12. The genital period encompasses much of later life. We include some later periods of life in the table to give you an idea of progression across the lifespan.

One of Freud's primary contributions to developmental psychology is his emphasis on how early experiences, especially in the first 6 years of life, influence later development. For him, the way in which the child negotiates the oral, anal and phallic stages has a profound impact on emotional development and the adult personality. For example, infants who have unsatisfied needs for oral stimulation may be more likely to smoke as adults. Although current developmental theory does not adopt

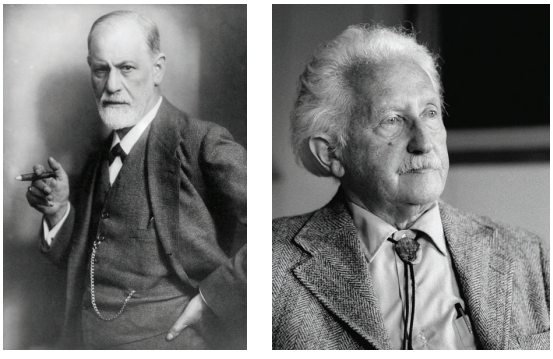
Table 2-1 Freud's and Erikson's developmental stages

Stage of development		
Age period	Freudian	Eriksonian
0–1	**Oral.** Focus on eating and taking things into the mouth	**Infancy.** Task: to develop *basic trust* in oneself and others Risk: *mistrust* of others and lack of self-confidence
1–3	**Anal.** Emphasis on toilet training; first experience with discipline and authority	**Early childhood.** Task: to learn self-control and establish *autonomy* Risk: *shame* and *doubt* about one's own capabilities
3–6	**Phallic.** Increase in sexual urges arouses curiosity and alerts children to gender differences; period is critical to formation of gender identity	**Play age.** Task: to develop *initiative* in mastering environment Risk: feelings of *guilt* over aggressiveness and daring
6–12	**Latency.** Sexual urges repressed; emphasis on education and the beginnings of concern for others	**School age.** Task: to develop *industry* Risk: feelings of *inferiority* over real or imagined failure to master tasks
12–20		**Adolescence.** Task: to achieve a sense of *identity* Risk: *role confusion* over who and what individual wants to be
20–30	**Genital.** Altruistic love joins selfish love; need for reproduction of species underlies adoption of adult responsibilities	**Young adulthood.** Task: to achieve *intimacy* with others Risk: shaky identity may lead to avoidance of others and *isolation*
30–65		**Adulthood.** Task: to express oneself through *generativity* Risk: inability to create children, ideas or products may lead to *stagnation*
65+		**Mature age.** Task: to achieve a sense of *integrity* Risk: doubts and unfulfilled desires may lead to *despair*

psychosocial theory Erikson's theory of development, which sees children developing through a series of stages largely through accomplishing tasks that involve them in interaction with their social environment.

Freud's exact views about early experience, the idea that Freud introduced – namely, that events in infancy and childhood have a formative impact on later development – remains an important theme in the study of social and emotional development. Psychodynamic theory has also been particularly influential in certain areas of applied and clinical psychology, as discussed in Chapter 15.

Freud had many followers who went on to devise their own theories of development, many of which contain concepts that stem from Freud's ideas. Erik Erikson devised one of the most prominent of these theories in his **psychosocial theory** of human development. In Erikson's theory, development is seen as proceeding through a series of eight stages that unfold across the lifespan. Each stage is characterized by the personal and social tasks that the individual must accomplish, as well as the risks the individual confronts if she fails to proceed through the stages successfully (see Table 2-1). Of these ideas, the most influential for current research in child development is the stage of adolescence, in which the child focuses on identity development and seeks to establish a clear and stable sense of self.



Sigmund Freud (1865–1939) and Erik Erikson (1902–1990). Freud was the father of psychodynamic theory. Erikson studied psychology in Vienna with Freud. His psychosocial theory continues to be influential today, especially for those who hold a lifespan perspective on development.
© Time & Life Pictures/Getty Images (L) © Corbis Historical (R)

Another central contribution that Freud's thinking makes to contemporary developmental psychology is the vital role that emotional attachment early in life, especially to the mother, has in socioemotional development. We will cover this in more detail in Chapter 7 but we will here cover an important figure who played an important role in shaping the psychoanalytic approach to address our understanding of early attachment – John Bowlby.

Ethological theory and John Bowlby

ethological theory
A theory which holds that behaviour must be viewed and understood as occurring in a particular context and as having adaptive or survival value.

Ethological theory, which was developed by biologists, contends that behaviour must be viewed and understood as occurring in a particular context, and as having adaptive or survival value. Since Charles Darwin introduced evolutionary theory (the idea that we have evolved as a species to be well suited to survive in our environment), other scientists have sought to understand both the evolution of behaviour and its adaptive, or survival, value to the species exhibiting it. You may have heard of a behaviour exhibited by young ducklings in which they appear to follow around an adult of an entirely different species (see photo). German ethologist Konrad Lorenz (1937) named this behaviour imprinting.

Konrad Lorenz and a group of ducklings who have imprinted to him.
© Thomas D. McAvoy/Getty Images

Lorenz described imprinting as a sudden, biologically primed form of attachment. It occurs in some bird species, including ducks and geese, and in a few mammals, such as shrews. Imprinting involves a critical period. In mallard ducklings, the strongest imprinting occurs within a day after hatching, and by two days the capacity to imprint is lost (Hess, 1959). Thus, in some species, offspring must be exposed to parents within hours or days after entering the world in order to attach to them. The important point about imprinting for ethologists is that despite the fact it can go wrong in some instances, it is a highly adaptive behaviour in that it serves to create a strong proximity between infant and parent.

Psychologists have also adopted ethological theory by also including mental processes like perception, cognition and emotion in this list of 'behaviours' which are adaptive and have survival value (Hinde, 1994; Bjorklund & Pelligrini, 2002). And as we will discuss in Chapter 7, some 'evolutionary' approaches to developmental psychology have suggested that some maladaptive behaviours (like adolescent risk taking) might also be explained by historical ethological pressures (Machluf & Bjorklund, 2015).

Central to the ethological line of thought is the necessity to view and understand the behaviour and mental processes of an organism in relation to its biology and the ecosystem in which it functions. So it is important to take into account environment and needs at different stages of development. For instance, the needs of a newborn baby in the arms of a parent are very different from those of a young child in a playground.

Ethologists' basic method of study is the observation of children in their natural surroundings, and their goals are to develop detailed descriptions and classifications of behaviour. For developmental psychologists, ethological theory is useful for understanding that many behaviours seen across a range of cultures, such as smiling and crying, may have a biological basis and play an important role in ensuring that caregivers meet children's needs. For example, crying can be viewed as an 'elicitor' of parental behaviour; it serves to communicate that a child is distressed or hungry. It thus has clear survival value, for it ensures that parents give the young infant the kind of attention she needs for adequate development.

Although human ethologists view many elicitors, such as crying, as biologically based, they also assume that these types of behaviour are modified by environmentally based experiences. For example, children may learn to mask their emotions by smiling even when they are unhappy (Kromm, Färber, & Holodynski, 2015; McDowell, O'Neil, & Parke, 2000). Thus, modern ethologists view children as open to learning and using input from the environment; they are not solely captives of their biological roots.

One particular focus of ethological theory has been the behaviours in human infants and children that are 'species specific' (unique to the human species) and that may play an important role in ensuring that others meet children's basic needs, which are critical to survival. Studies have found, for example, that emotional expressions of joy, sadness, disgust and anger are similar across a wide range of cultures (Ekman

et al., 1987; LaFreniere, 2000). Others have argued that imitation is a behaviour which humans are specialized in, and which enables us to learn particular things from our environment (Csibra & Gergely, 2009; Meltzoff & Prinz, 2002), although this idea is rather controversial (Farmer, Ciaunica, & Hamilton, 2018; Heyes, 2016).

Perhaps the area of developmental psychology that has been most greatly influenced by the ethological approach is the study of early relationships. The key ethological theorist who considered the adaptive value of early human relationships was John Bowlby (see Research Close-Up). Bowlby proposed the maternal deprivation hypothesis, in which he suggested that attachment bonds between infant and parent in the first years of life are vital to ensure well-adjusted socioemotional development. As you will see in Chapter 7, although some of the details of Bowlby's account have been challenged, his ideas continue to be very important in our understanding of early emotional bonds.

Bowlby's maternal deprivation hypothesis took a great deal of inspiration from ethology. Bowlby's approach set the scene for modern empirical research into parent–infant attachment (see Chapter 7).

As well as being rooted in the psychoanalytic tradition beginning with Freud, Bowlby's maternal deprivation hypothesis took much inspiration from ethological theory. The idea that a certain kind of experience (bonding with a parent) at a critical stage in development is vital for the normal development of attachment relationships can be traced back to ethologists like Lorenz's observations concerning imprinting.

BOX 2-1 44 Thieves

Research close-up

Source: Based on Bowlby (1944).

Introduction:

In 1944 John Bowlby, a famous psychoanalyst, was following up his ideas about how maternal deprivation early in life could result in problems in forming close relationships with others. Bowlby was particularly interested in, and had worked a great deal with, young adults who had difficulty with giving or receiving affection from others, and those who demonstrated delinquent behaviour. At the time in Britain, the vast majority of indictable criminal offences were for theft of some kind, and many (about half) of those offences were committed by people under 21 years of age. In order to examine whether there was any evidence for his view that delinquent behaviour was caused by maternal deprivation of some kind, Bowlby conducted a study of the backgrounds of 44 juvenile delinquent thieves.

Method:

Bowlby conducted clinical interviews with 44 juveniles who had been referred to a 'child guidance' programme in London because they had been suspected of theft (not all had actually been convicted). Bowlby also selected a control group of children who had also been referred to the child guidance programme, but not because of theft. The control group were similarly composed in terms of age and intelligence to the 'theft' group. Bowlby reported his observations concerning the psychopathology of 44 juvenile delinquent thieves, and examined the links between their delinquency, their psychopathology and the environment in which they had grown up. Bowlby specifically attended to long separations from the children's mother early in life.

Results:

The central finding was that a substantial proportion of the juvenile thieves (17 of 44) had been separated from their mothers for longer than six months in the first five years of their life. In the control group only two of the children had had such a separation. Bowlby also reported that several children in the thieving group showed 'affectionless psychopathy' and, of those, 12 had experienced maternal deprivation for longer than six months before the age of five.

Discussion:

This study, among other observations, reinforced Bowlby's view that maternal deprivation in early life leads to socioemotional difficulties, particularly in forming relationships with others. He was particularly concerned with the strong relationship between maternal deprivation and affectionless psychopathy.

Although this study is an important contribution to the literature, there are a number of problems of interpretation. Could there be a different direction of causation at play than the one Bowlby thought important? For instance, it is possible that the affectionless psychopaths had inherited those traits from their parents (including their mother). In which case it might not be surprising that their mothers spent time apart from them early in life. In current theoretical approaches, researchers tend to consider how genetic and environmental contributions can work together in these kinds of situations. Perhaps the affectionless psychopathy Bowlby observed was due to both maternal deprivation and inherited traits (Price & Jaffee, 2008). Also, as we shall see in Chapter 7, although Bowlby's maternal deprivation hypothesis has been influential, a number of aspects of it have been challenged and revised.

GRAND THEORIES OF COGNITIVE DEVELOPMENT

Researchers interested in cognitive development attempt to describe the development of internal mental processes such as memory, logic and language. In the early to mid-twentieth century, behaviourism was the dominant force in explaining not just development, but behaviour in young and mature animals and humans alike. However, whilst behaviourism placed little importance on internal mental processes, more and more psychologists began to argue that there was more to psychology than simple associative learning mechanisms such as classical and operant conditioning.

One set of observations which were a particular problem for behaviourists concerned more creative kinds of learning which cognitive psychologists would now call spontaneous (or insightful) problem solving. Some researchers (e.g., Köhler, 1947) even began to demonstrate that animals could solve problems by thinking about them (rather than by being shaped by their experiences, which was the basic tenet of the behaviourist position). This movement towards a consideration of internal mental processes led to the birth of cognitive psychology (Neisser, 1967). However, perhaps the most important figure in sealing the doom of behaviourism as an all-encompassing explanation for psychology came from a developmental perspective. Jean Piaget, as we shall see, described sudden (insightful) shifts in knowledge in young children in which he argued that they moved from one developmental stage to the next.

Sudden developments in ability or behaviour were not well accounted for by mainstream behaviourist positions in the mid-nineteenth century. However, before we discuss Piaget's explanation for qualitative (stage-wise) developmental change, we will cover one approach to explaining development which emerged straight out of behaviourism, and was able to account for a wider range of developmental phenomena: social learning theory.

Social learning theory

According to **social learning theory**, children learn not only through classical and operant conditioning but also by observing and imitating others in what has been called **observational learning** (Bandura, 1989, 1997). In his classic studies, Albert Bandura showed that children exposed to the aggressive behaviour of another person were likely to imitate that behaviour. For example, after a group of nursery school children watched an adult punch a large Bobo doll (an inflated rubber doll that pops back up after being pushed), the children were more likely to attack and play aggressively with the doll than were a group of children who had not seen the model. Neither the adult model nor the children had received any reinforcement, yet the children learned specific behaviours.

social learning theory
A learning theory that stresses the importance of observation and imitation in the acquisition of new behaviours, with learning mediated by cognitive processes.

observational learning
Learning that occurs through observing the behaviour of others.

Further research on how the process of imitation aids learning has revealed the important contribution of cognition to observational learning. Children do not imitate the behaviours of others blindly or automatically; rather, they select specific behaviours to imitate, and their imitation relies on how they process this information. According to Bandura, four cognitive processes govern how well a child will learn a new behaviour by observing another person (Figure 2-1). First, the child must *attend* to a model's behaviour. Second, the child must *retain* the observed behaviours in

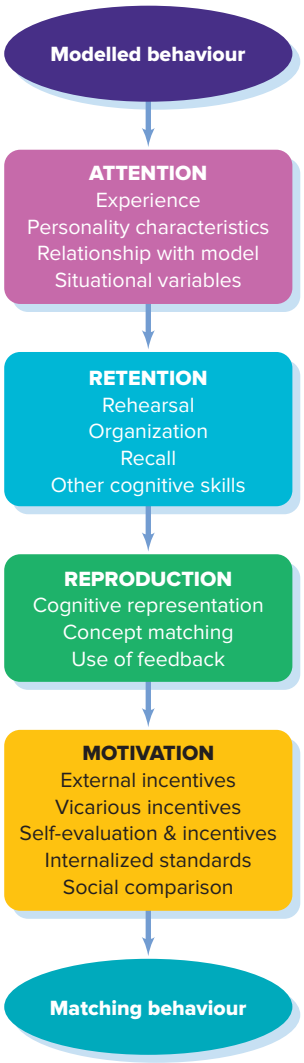


Figure 2-1 Bandura's model of observational learning

According to Bandura, to produce a behaviour that matches that of a model, a child goes through four sets of processes. Her ability to attend to the modelled behaviour is influenced by factors in her own experience and in the situation; her skill in retaining what she has observed reflects a collection of cognitive skills; her reproduction of the behaviour depends on other cognitive skills, including the use of feedback from others; and her motivation to produce the behaviour is influenced by various incentives, her own standards and her tendency to compare herself with others.

Source: Based on Bandura (1989).

memory. Third, the child must have the capacity, physically and intellectually, to *reproduce* the observed behaviour. Fourth, the child must be *motivated*, that is, have a reason to reproduce the behaviour.

As we shall see in Chapter 10, observational learning, and particularly imitation, continues to be a topic of much debate and controversy. As an important means by which we can learn from our social and cultural environments, these learning processes have wide-reaching implications across and beyond developmental psychology. As well as debating questions about precisely when and how imitation becomes available to infants and children as a learning mechanism (e.g., Meltzoff & Prinz, 2002; Heyes, 2016a), researchers and theorists have also argued about whether there is more to imitation than is suggested in Bandura's model (e.g., Gergely, Bekkering, & Király, 2002; Heyes, 2016b).

Piaget's constructionism

As we have already mentioned, perhaps the most famous theoretical account of cognitive development was proposed by Jean Piaget, a developmental psychologist based in Geneva. The body of work Piaget published as a result of his research led him to become probably the most influential developmental psychologist of the twentieth century. As we will be discussing **Piaget's theories** in great detail in Chapter 9 we will only briefly introduce his ideas here.

Piaget began his own scientific research at a considerably younger age than most other people do. His primary interest was biology, and at the age of 10 he published his first scholarly article on the rare albino sparrow. As Piaget continued his studies, his interest in biology continued. However, he also became interested in philosophy, especially the study of knowledge, or *epistemology*. As a young man, Piaget pursued these interests by studying in Paris with Alfred Binet, who was working on the development of the first intelligence test (discussed in Chapter 11). As he helped Binet develop standardized IQ tests for children, Piaget made two important observations. First, he noticed that children of the same ages tended to get the same answers wrong. Second, he noticed that the errors of children of a particular age differed in systematic ways from those of older or younger children. Piaget's theory of cognitive development began to take shape as he thought about these errors; in particular, he thought they revealed distinct age-related ways of thinking and understanding the world. The key to understanding how children think, Piaget believed, was not whether they got the right answers but *how* they arrived at their answers.

Piagetian theory
A theory of cognitive development that sees the child as actively seeking new information.

A developmental psychologist at the Universities of Geneva and Lausanne, Switzerland, Jean Piaget (1896–1980) framed a theory of the child's cognitive development that has had great impact on developmental scientists, educators, and others concerned with the course and determinants of children's development.

Lev Vygotsky (1895–1934) was a Byelorussian born psychologist who worked, predominantly in the former Soviet Union, at the Psychological Institute and founded the Laboratory for Abnormal Childhood in Moscow. He developed many ideas in developmental science including the idea of a 'zone of proximal development' for understanding children's psychological growth.

Piaget introduced a constructionist theory to describe intellectual development (e.g., Piaget, 1951). The origins of this theory can be observed from early in Piaget's career when he was working with Alfred Binet. He proposed that children's thinking changes *qualitatively* with age and that it differs from the way adults think. Piaget believed that cognitive development results from a process of development in which children actively construct their own development by coming up with theories and testing them. He believed that this predilection to actively acquire the environment (to construct abilities and knowledge) interacted with the experiences brought about by this activity in order to determine how the child develops. In a nutshell Piaget viewed children as 'little scientists' who actively seek to understand their world.

Piaget proposed that all children go through three periods of cognitive development, each characterized by qualitatively different ways of thinking. We outline these periods in detail in Chapter 9. In brief, though, Piaget described that infants rely on their sensory and motor abilities to learn about the world, preschool children rely more on mental structures and symbols, especially language. In the school years, children begin to rely more on logic and, in adolescence, children can reason about abstract ideas. According to Piaget, cognitive development is a process in which the child shifts from a focus on the self, immediate sensory experiences and simple problems, to a more complex, multifaceted and abstract understanding of the world.

Vygotsky and sociocultural development

One of the major criticisms of Piaget's approach was that he did not take enough into account the social environment of the child. **Sociocultural theory** places particular emphasis on the impact of social and cultural experience on child development. This approach traces many of its roots to the writings of Lev S. Vygotsky, a Russian psychologist who worked in the early part of the twentieth century (at a similar time to Piaget).

sociocultural theory
A theory of development, proposed by Lev Vygotsky, that sees development as emerging from children's interactions with more skilled people, and the institutions and tools provided by their culture.

Vygotsky grew up in the early twentieth century, which was a time of tumultuous social change in Russia (Kozulin, 1990). In 1917, the year Vygotsky graduated from Moscow University, the Russian Revolution began and the entire society was in upheaval. After the Revolution, as Vygotsky launched his career as a psychologist and developed his theory, civil war and famine ravaged the country, and the entire social structure of the nation changed dramatically. Although some aspects of Vygotsky's life improved, others did not. At the time of his death at age 37 from tuberculosis, he had fallen into political disfavour in Stalinist Russia and his work was banned. As a result, it wasn't until the late 1970s that psychologists in the United States and other parts of the world began to explore Vygotsky's ideas (Wertsch & Tulviste, 1992).

Vygotsky's theory (e.g.,Vygotsky, 1978) proposes that the child's development is best understood in relation to social and cultural experience. Social interaction, in particular, is seen as a critical force in development. Through the assistance provided by more experienced people in the social environment, the child gradually learns to function intellectually on her own. Thus, the social world mediates individual cognitive development.

By emphasizing the socially mediated nature of cognitive processes, this approach offers new ways of assessing children's cognitive potential and of teaching reading, mathematics and writing (Brown & Campione, 1997; Hyson, Copple, & Jones, 2006). A vivid example in the classroom is peer tutoring, in which an older child helps a younger pupil learn to read, write, add, subtract, and so on.

Sociocultural theory has also increased our appreciation of the profound importance of cultural variation in development. The ways in which adults support and direct child development are influenced by culture, especially the values and practices that organize what and how adults and children think and work together,

and use cultural tools to understand the world and solve cognitive problems. These tools are devised by cultures and they take a variety of forms, including language, mathematical symbols, literacy and technology. As children develop, different tools help them function more effectively in solving problems and understanding the world. Thus, tools of thinking, which are products of culture, become incorporated into the ways individuals think about and act in the world. We discuss this theory at greater length in Chapter 8. Throughout the book, many culturally based examples will touch back to this theory.

Nativist theories of cognitive development

Another group of modern theories of cognitive development have appealed to the idea that (some of) our cognitive abilities are innate, provided by our genetic inheritance. This is a direct extension of the arguments of the rationalist philosophers who we discussed at the outset of this chapter. One of the most important figures among nativist theories is Noam Chomsky, who argued that we inherit an innate mental structure which helps us to learn language.

In Chapter 8 we will discuss how children learn language. Chomsky has argued that our inheritance provides us with a mental structure which enables us to do this.

Another kind of nativist account argues that we not only inherit a particular *mental structure*, but we are also born with innate *knowledge* about specific aspects of our worlds. This argument has been made particularly forcefully by Elizabeth Spelke in her 'core knowledge' account (see Chapter 9), which proposes that infants are born with knowledge of, among other things, the permanence and solidity of objects.

Nativist accounts of cognitive development obviously owe a lot to Darwin's theory of evolution, as the argument is that our inherited knowledge (and/or mental structure) has been provided through evolutionary selective forces. However, it is important to realize that Darwin and the theory of evolution play central roles in all modern theories of development, not just the modern nativist theories of Spelke and Chomsky. For instance, although one might consider behaviourism's emphasis on the role of experience in shaping development to be at odds with concepts of inheritance and evolution, behaviourism actually owes much to Darwin; behaviourism appeals to evolution as a means of explaining the learning mechanisms with which animals and humans adapt to their environments (Costall, 2004). As we have already seen, ethological theory also owes much to Darwin's theory of evolution as it seeks to understand how our inheritance provides us with adaptive behaviours.

evolutionary psychology
An approach which holds that critical components of psychological functioning reflect evolutionary changes and are critical to the survival of the species.

Nativist theories of cognitive development can be described as having a particular relationship to evolutionary theory as they fall under the somewhat more narrow umbrella of **evolutionary psychology**. Evolutionary psychological theories can be contrasted with ethology as, rather than describing inherited behaviours, evolutionary psychologists have examined how our inheritance can play a role in the development of internal *cognitive processes*. Indeed, some of the leading proponents of evolutionary psychology argue that the critical components of human evolutionary change are in the areas of brain changes underlying cognitive functioning (Cosmides & Tooby, 1987).

A number of modern nativist developmental theories are strongly influenced by an argument developed by Jerry Fodor in his book *Modularity of Mind* (Fodor, 1983). In this book, Fodor argued that many of the cognitive functions humans possess are subserved by modules that are especially designed to process specific kinds of information. A good example of such a module might be a specialized system for learning language, like the 'language acquisition device' proposed by Noam Chomsky (see Chapter 8). Fodor argued that such modules are 'computationally encapsulated', that is, they process information in the way they have been designed, but autonomously and out of the influence of other aspects of mental functions (and other modules).

In developmental terms it is easy to see how such modules could fit well with a nativist account of cognitive development. Our inheritance could specify cognitive modules, meaning that we just have to wait until the brain and body mature until such modules come into action and help us to think about the world in ways which evolution has prepared us for. A number of such arguments have been made. For example, evolutionary developmental theorists have argued that we have an innate (i.e., inherited) ability to acquire language (Chomsky, 1965; Pinker, 1994; Pinker & Jackendoff, 2005), that we have innate cognitive modules that help

Alison Gopnik has argued that our inheritance provides us with a propensity to learn about the world around us by forming theories and testing them.
© Alison Gopnik

us understand others' minds (Leslie & Thaiss, 1992; Leslie, Friedman, & German, 2004), and innate knowledge about objects, number, and our spatial environment (Carey, 2009; Spelke et al., 1992; Shusterman, Lee, & Spelke, 2008).

So where does development fit into the picture? If we have so many cognitive modules provided by our inheritance, then why do children take so long to develop mature cognitive abilities? Actually a number of these evolutionary theories of development argue that while some aspects of cognitive functioning are innate, some are acquired through experience (e.g., Spelke et al., 1992). Also, rather like the maturationists of the early twentieth century, many modern evolutionary developmental psychologists also argue that innate modules emerge according to maturational timetables (Carey, 2009; Diamond, 1988; Bjorklund & Pelligrini, 2002).

Many developmental psychologists argue that it is going too far to say that we are born with knowledge or cognitive modules as such (e.g., Elman et al., 1996; Mareschal et al., 2007). But the Chomskyan idea that we are born with a particular *mental structure* to think about the world is perhaps a little more accepted. One account of this kind has been advanced by Alison Gopnik. Gopnik (e.g., Gopnik, 2017) argues that we are born with the means to think about the world around us, to form theories about why we have observed certain things, and to gather evidence to check whether or not our theories are true. Her argument is that we are all born to be scientists, prepared to think about and test our ideas about the world around us. In some ways this brings us back to Piaget, and his idea that we are given the tendencies to actively acquire and learn from our environments.

Another account which proposes that we have some specific innate tendencies, rather than knowledge as such, is put forward by Csibra and Gergely (2011). As we shall see in Chapter 9, they argue that there is an innate, or natural, pedagogy, in which we are born with predispositions to attend to and draw in the social world around us in a way which will best help us learn from the teachers which it offers up; even those teachers, like carers, parents, or siblings who do not have a formal teaching qualification!

INFORMATION PROCESSING AND COMPUTATIONAL ACCOUNTS OF COGNITIVE DEVELOPMENT

Information processing approaches to development are a broad grouping of theoretical accounts that have been inspired from a tradition of models of cognitive abilities in adult humans. At the same time that Piaget and Vygotsky's approaches to describing the origins of knowledge were becoming popular, a movement among researchers studying cognitive abilities in adults, called the 'information processing' approach, was trying to characterize the flow of information through the cognitive system, beginning with an input or stimulus, proceeding to processing of that information (e.g., perceptual elaboration, attention, memory storage) and ending with an output or response, much like the way computers process information (Munakata, 2006). In human information processing, output may be in the form of an action, a decision or simply a memory that is stored for later use.

information processing approaches Theories of development that focus on the flow of information through the child's cognitive system and particularly on the specific operations the child performs between input and output phases.

And so the information processing approach to development attempts to understand how the cognitive processes that an adult uses (memory, attention, perception, motor control) develop over the lifespan. One particular question raised concerns what cognitive processes children of different ages can use. For instance, a question

that has received particular attention concerns when we first develop the ability to store long-term episodic memories. This approach has been applied to a wide range of topics in cognitive development, including attention, memory, problem solving and planning. Information processing theory has also proved valuable in studying how children develop an understanding of reading, mathematics and science (Siegler, 2000; Siegler & Alibali, 2005) as well as social behaviours, such as social problem solving and aggression (Lemerise & Arsenio, 2000; Kupersmidt & Dodge, 2004).

In Chapter 10, we examine the information processing approach more closely in relation to the development of thinking and problem solving. However, here let's look at a few broad classes of information processing accounts.

Neo-Piagetian information processing accounts

Neo-Piagetian theories of information processing attempt to integrate Piaget's ideas with an information-processing perspective. According to Case (1992, 1998), the proponent of one of these theories, the stage-like development of cognition described by Piaget is based on improvements in memory capacity and executive control, two features of an information-processing system. Like Piaget, Case divides development into stages. Each of the proposed stages entails an increasingly sophisticated **executive control structure**, which is a 'mental blueprint or plan for solving a class of problems'. An executive control structure has three components (Case, 1984): a representation of the problem, a representation of the goal of the problem, and a representation of a strategy for attaining the goal. Case and his colleagues applied this theory to a variety of tasks and domains, including scientific reasoning, the analysis of social problems and mathematics (see Case, 1998, for a review of this research).

neo-Piagetian theories Theories of cognitive development that reinterpret Piaget's concepts from an information-processing perspective.

executive control structure According to Case, a mental blueprint or plan for solving a class of problems.

connectionist models Connectionist models are a class of computational model used to make explicit theoretical accounts of human cognition and development.

Computational accounts of development

A criticism of developmental psychology which has come to the fore in the twenty-first century (Munakata & Johnson, 2005) has been that we are finding out relatively little about the processes by which developmental change happens. How precisely do nature and nurture interact? Piaget of course had his ideas about this which we've talked about already. He proposed that the child plays an active role in constructing her/his development through exploring their own environment. But then if we probe any further, it is difficult to get to a very precise account of the mechanisms by which this might work. The neo-Piagetians' ideas are perhaps even more difficult to pull out. Why is it exactly that children develop increasingly sophisticated control structures, as Case argued? These challenges have led information processing theorists to try to develop more precise models of how cognitive development happens, models which attempt to specify how the mind/brain computes information, and how those computations can drive developmental change. These are 'computational models' of development (Bonawitz et al., 2014; McClelland et al., 2010; Perfors et al., 2011; Shultz, 2013).

CONNECTIONIST MODELS OF DEVELOPMENT

A particular type of computational developmental account which gained a great deal of attention around the turn of the century is connectionist modelling (Elman et al., 1997; Mareschal et al., 2007; McClelland et al., 2010; Shultz, 2013). **Connectionist models** consist of a large set of interconnected nodes, rather like a network of neurons in the brain (connected together through their synapses). These nodes and connections (see Figure 2-2) are not usually put together in physical form. They are typically simulated in a virtual environment on a computer. Connectionist models process information; a pattern of input activations is fed in to the network at one end and that pattern is then transformed into an output at the other end. As such these networks represent precise theories of how information might be processed in a neural network. Some connectionist theorists (or 'modellers') attempt to emulate exactly how the brain

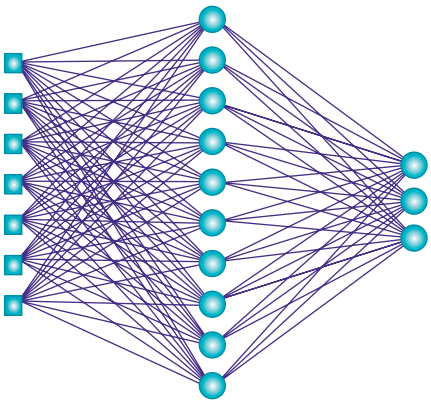


Figure 2-2 A connectionist model
This particular model has seven input nodes (the squares on the left), fully connected to three output nodes, through a large middle 'hidden' layer of ten nodes. Connectionist models learn via changes in the strengths of connection between each layer of nodes.

processes information (by programming the computer to simulate how neurons would function in the brain; e.g., Rolls & Treves, 1998). Other modellers are less concerned with simulating exactly how the brain works, but more with using connectionist models to show how cognitive computations can be made (Rumelhart & McClelland, 1986).

But how do these connectionist models simulate development? The way these models learn is again similar to how networks of neurons in the brain learn. They learn by altering the strengths of connections between the nodes, rather like synapses between neurons change strength in the nervous system and brain. Changes in these connection strengths result in sensory input being processed and transformed in new ways, leading to new ways of the network responding to that input. Imagine a network that is learning to read. It has to transform a pattern on the page (the input) into some appropriate speech sounds (the output). If the network's connections are changed in such a way to respond to the errors it makes and improve its performance then it will eventually find a set of connection strengths that enable it to read. We can imagine the same scenario in human development. Initially the networks of neurons in our brains are naive, the connections between various neurons mean that our responses to stimuli in the environment will produce a naive response (if you ask a pre-reading child to name a word written on the page you are likely to get an odd response). But gradually, as we are exposed to reading practice and tuition, the neural networks in our brain retune in order to produce accurate reading. In the Research Close-Up box, we show how a connectionist model can explain early visual categorization in young infants.

The connectionist modelling approach typically places a lot of emphasis on how the environment to which we are exposed shapes our learning and development (Elman et al., 1997; Mareschal et al., 2007). Usually, models learn by changing weights in specific response to the input patterns that are provided to the models (and sometimes the subsequent outputs that models produce). Thus the input to which the model is exposed shapes its development. In that sense, connectionism is rather similar to behaviourism. The similarity does not end there, as connectionist models learn by associating inputs with particular outputs. These are more complicated versions of the associative learning mechanisms that the behaviourists advocated. However, a particular contribution of modern connectionism is that it has shown us that associative learning in such networks can result in sudden, stage-like changes in behaviour over time. In that sense they represent a link between behaviourism and Piaget – like Siegler's overlapping waves model (which we discussed in Chapter 1) they show how insightful shifts in development can arise from gradual shaping of behaviour.

Research close-up

BOX 2-2 A connectionist model of early categorization

Source: Based on French et al. (2004).

Introduction:

As we shall see in Chapter 9, a puzzle that has interested developmental psychologists for a long time concerns how we come to be able to form categories. Imagine if you were not able to do this. Every object you saw would be entirely new. Without the knowledge that the new animal you see on your way to lectures is a cat, you would have no point of reference from which to predict its behaviour – should you

stroke it, say hello, or might that be a fatal mistake? Thankfully we try to place animals and objects we see into categories so that we can learn that animals that fit a certain set of criteria behave in similar ways (we know that medium small furry animals with tails, whiskers, large eyes and meowing calls are cats and so we can predict that they will, usually, respond well to a stroke). Infants are no exception. Studies measuring young infants' visual fixations show that they form separate categories. In one study, infants were shown a series of pictures of different cats. Over time their interest in them declined (as shown by a decline in their visual fixation of the pictures). A dog picture was then introduced, paired with another new cat picture. The infants showed a preference to look at the dog even though they had not seen either the dog or the cat before (Quinn, Eimas, & Rosenkrantz, 1993). This shows that infants formed a visual category of cats which excluded the dog.

However, an unusual finding was observed with this study. Quinn et al. (1993) found that when 3- to 4-month-olds are initially exposed (habituated) to a series of pictures of dogs (rather than being initially exposed to cats) they will not perceive a new cat as being more novel than a new dog. So, when learning about cats, young infants appear to treat dogs as new, but when learning about dogs, they treat cats as the same as dogs.

Method:

Mareschal and colleagues (Mareschal, French, & Quinn, 2000; Mareschal & French, 2000) set out to explain this strange finding, and to understand infant categorization behaviour more generally by constructing a connectionist model. They used a particular kind of model called an 'auto-encoder'. Auto-encoder networks attempt to find a set of connection strengths that enable them to form representations of any input pattern presented to them. After training, the auto-encoder manages to do this better with some patterns than with others. Typically, it is the patterns that are least similar to what the network has learned from in the past that it makes the most errors in reproducing. So, we can imagine that the error the network makes when reproducing corresponds to the novelty of the stimulus to which it has been exposed. Mareschal et al. used the encoder in this way to model a looking preference in infants. They used the model's error in reproducing a pattern as corresponding to the amount of looking that infants direct towards a given stimulus.

Results:

So the auto-encoder was trained up on cats and dogs, just like the infants were in Quinn et al.'s experiments. The way Mareschal et al. exposed the auto-encoder to the pictures was to measure a set of dimensions in each of the pictures (e.g., nose length, leg length, distance between the ears) and present the figures to networks for categorization. Interestingly the networks developed CAT and DOG categories with the same asymmetry as the 3- to 4-month-olds in Quinn et al.'s study; if trained on cats, the networks showed error when presented with a novel dog, but if trained on dogs, the networks were more accurate at reproducing a representation of a novel cat.

A closer look at the network allowed Mareschal and French to explain why the networks behaved like this. Most cat features (ear length, nose length, etc.) fell within the range of the dog values to which the network had been trained, but the converse was not true (i.e. there is more variation between dogs in these features than there is between cats). The auto-encoder had learned to categorize on the basis of the statistical distribution of features of the stimuli to which they had been presented. Mareschal and French (2000) argue that the same is true for infants.

Discussion:

Here we see quite clearly how a particular class of connectionist model (an auto-encoder) helped explain confusing behavioural findings, by forming an explicit mechanistic theory of that behaviour with testable hypotheses. In this case the model helped demonstrate that infants form categories for visual objects on the basis of the statistics to which they are exposed, rather than by using any 'top down' knowledge.

BAYESIAN MODELS OF DEVELOPMENT

A group of computational accounts of development which have gained particular interest in the last decade or so involve what is called **Bayesian modelling** (Bonawitz et al., 2014; Gopnik & Tenenbaum, 2007; Perfors et al., 2011). Thomas Bayes, who these models are named after, was an eighteenth-century statistician who came up with **Bayes's theorem**.

Bayes's theorem describes something called conditional probability – the probability that something is the case given the knowledge that something else is true (e.g., the probability that a young child has chicken-pox given that she has lots of spots appearing on her face). Bayesian modellers construct networks of conditional probabilities in order to provide explicit theories of why we believe certain things, or for instance why we perceive objects in particular ways, based on our knowledge of the world around us or at least our knowledge of what is happening right now.

The broad idea of Bayesian models is that our brains/minds use prior knowledge and conditional probabilities to form our understanding of the world around us. In developmental psychology, Bayesian modelling has been used to explain how children develop in their knowledge of the world. Theorists such as Gopnik (2017) have argued that children develop their understanding of the world through a 'scientific' Bayesian 'sampling'. She argues that children have naive theories about the work, which they then test out by applying to novel situations. When their predictions turn out to be true or false they update their Bayesian predictions accordingly, so that next time they encounter something similar they can predict what will happen more precisely.

Bayesian modelling
A form of computational modelling which rests on conditional probabilistic relationships between items of information. Bayesian modelling is used to model the development of children's understanding of the relationships between many things, including events, words and objects.

Bayes's theorem
Bayes's theorem describes conditional probability; that is, the probability of an event based on prior knowledge that something else which might be related to the event is the case or has occurred.

dynamic systems accounts of development
Dynamic systems are an area of study in mathematics which attempts to describe complex systems with many inputs which interact in complex ways. Developmental psychologists have tried to explain development in this way.

Let's think about Bayesian learning in the context of word learning. If a child hears an adult refer to a bunch of paper as a 'newspaper', he or she might, when they next see a newspaper or a magazine, test out their idea of this, waiting to hear what an adult will call the object (or even trying the word newspaper out themselves). They might turn out to be right or wrong, but if they learn to update their predictions, then they will have learned.

This all might sound a bit like the kinds of 'associative' learning which the behaviourists were so fond of, and it might also sound rather like the connectionist computational models which we were just discussing (where the strength of the connection is changed based on associations in a learning episode). There are certainly some similarities. However, the key thing about Bayesian modelling is that it provides a straightforward way to capture how a brain or mind makes predictions on the basis of what it knows. Gopnik (Gopnik & Wellman, 2012) argues that this is what children do. In fact, it is reasonable to say that Piaget said this too. The difference is that Piaget argued that children constructed their own ability to do this through development, whereas Gopnik (2017) argues that children are born with this ability.

DYNAMIC SYSTEMS ACCOUNTS OF DEVELOPMENT

Working with babies is chaos! Honestly, who would be a developmental psychologist? The beauty of **dynamic systems accounts of development** is that that they embrace this chaos, treating it as a natural part of development. Dynamic systems are an area of study which comes from mathematics. The idea is to be able to describe change in a complex system which has many inputs to its behaviour. Think of a 6-month-old baby. Not long from being a newborn muddle of reflexive motor behaviours, the baby is bombarded with sensory information from across all of its senses. It also has a bunch of desires (biscuit, Daddy, remote control) all vying for its attention. All of these desires, behaviours, sensory inputs are happening at once, with different time courses, and different strengths of action in the baby. Dynamics systems modelling can be used to describe how a baby's or a child's behaviour might result from the chaotic interactions of all of these inputs to the system (Smith & Thelen, 2003).

As well as describing the time course of behaviour, dynamic systems accounts can describe how development unfolds over time. Given that developmental processes

are also fundamentally to do with change over time, this can be a very helpful conceptual tool. Think of how one developmental outcome (for instance, learning first words) feeds into other outcomes (e.g., the development of conversation and communication skills) which in turn feed into learning further words. In this way development can be viewed as part of a dynamic system where change in a process (e.g., language development) is not linear and depends upon previous developmental change and the broader developmental and environmental context.

Like connectionist models, one of the great benefits of the dynamic systems approach is that it can explain how sudden (stagewise) developmental changes can result from the complex interactions of multiple quantitative changes. Also, as we shall see in Chapter 6, dynamic systems accounts have helped highlight the importance of thinking about all potentially relevant inputs to the developing system. In the 1980s, Esther Thelen's renowned research helped show how things you might not immediately think of, like increases in the weight of an infant's legs, were just as (if not more) important in explaining the development of their motor abilities than were things which might more typically spring to the developmental psychologist's mind (like the maturation of motor cortex, for instance).

In Chapter 6 we describe how a dynamic systems approach has been used to explain motor development in young infants.

NEUROSCIENCE AND DEVELOPMENTAL THEORIES

In recent years, developmental psychologists have begun turning their attention towards methods that can tell us about the development of the neural processes that underlie our psychological abilities. As we discuss in Chapter 3, the refinement of non-invasive techniques for studying neural responses in infants and children (e.g., EEG, fMRI, fNIRS) has led to a substantial increase in what we know about the development of human brain function.

These methods have revealed some exciting and interesting patterns of development in how infants' and children's brains respond while they are perceiving and processing information. The key debate, though, is how developmental changes in neural function arise. Mark Johnson at the University of Cambridge proposes some alternative ways of envisaging changes in brain function over development (Johnson, 2011). One approach, the 'maturational' account of brain development, suggests that the development of perceptual and cognitive abilities is held up by the maturation of relevant parts of the brain (for example, children may take a long time to master tasks where they have to inhibit a behaviour because their frontal cortex – responsible for inhibition – takes longer to grow than some other parts of the brain). Nativist theorists who, as we have discussed, take the view that many of our cognitive abilities are provided by our inheritance (e.g., Spelke, 1998; Leslie, Friedman, & German, 2004), generally adhere to a maturational position. This view thus implies that brain areas are specialized for particular tasks (e.g., face perception or Theory of Mind) but that the functioning of these brain areas occurs without the need for a major input of information from the environment.

Another approach, favoured by Johnson (2011), is the 'interactive specialization' account. Unlike the maturational account, interactive specialization suggests that particular parts of the brain are not predesigned for specific tasks, but rather that the brain becomes gradually specialized into different areas and networks that specialize at different tasks. Importantly, interactive specialization also argues that the environment to which infants and children are exposed plays an important role in shaping brain specialization.

But which approach is the correct one? It is certainly early days in answering this question, and it is important to acknowledge that maturation and interactive specialization could both be going on at once. However, evidence showing that the regions involved in particular tasks (e.g., in face perception; Halit, de Haan, & Johnson, 2003; Cohen-Kadosh et al., 2013) change substantially over development provides support for Johnson's interactive specialization account.

SUMMARY

As we stress throughout this book, the understanding of children's development can be approached from many perspectives. You can see from even the brief descriptions of the theories we have covered in this chapter that they have differing positions on several fundamental aspects of development (e.g., continuity vs stages, the role of nature vs nurture).

Although the presence of different theories adds a layer of complexity to studying child development, many questions about development benefit from these multiple theoretical perspectives. As well as giving us much to think about via these multiple perspectives on the same problem, it is important to realize that theories do not have to be mutually exclusive. While Freud and Piaget chose to describe development in quite different ways (Freud placing emphasis on needs and motivations, and Piaget focusing on logic and understanding), their different emphases do not necessarily contradict each other. Nonetheless, it is increasingly clear that different aspects of development, such as language and emotional and social behaviour, are interlinked. For instance, children's learning takes place in social contexts, and the experiences and relationships children have with other people affect what and how they learn from them. To understand such complex processes, several theoretical points of view are needed.

Many developmental psychologists today draw on some of the assumptions of several different approaches. It seems that several theories can tell us a great deal more about the causes and course of children's development than any single one can alone.

Explore and Discuss

1. What do you think the hallmarks of a good theory of development are?
2. Can you compare the theories of development discussed in this chapter in terms of their emphasis on nature vs nurture?

Recommended Reading

Classic

Flavell, J. H. (1963). *The developmental psychology of Jean Piaget*. Princeton, NJ: D. Van Nostrand.

Karmiloff-Smith, A., & Inhelder, B. (1974). If you want to get ahead, get a theory. *Cognition*, *3*, 195–212.

Contemporary

Crain, W. (2015). *Theories of development: Concepts and applications*. Hove: Psychology Press.

Gopnik, A. (2017). How babies think. *Scientific American*, *26*, 48–53.

Mareschal, D., Johnson, M. H., Sirois, S., Spratling, M., Thomas, M., & Westermann, G. (2007). *Neuroconstructivism: Vol. I. How the brain constructs cognition*. Oxford: Oxford University Press.