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Piagetian Theory of Cognitive Development

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Traditionally, cognitive development (see *Studying Cognitive Development in School-Aged Children*) focuses on two questions: What changes are observed throughout development in terms of depth of understanding, robustness of reasoning and the ability to solve problems, and the differential accumulation and effectiveness of knowledge acquisition? And how and why do changes occur? Jean Piaget (see *Piaget's Theory*), major founder of and pioneer in the field of cognitive development for many years, was the first scholar to give substantive answers to these questions.

To fully comprehend his view on cognitive development, one must be aware of Piaget's scientific origins. Piaget was a biologist, interested in the study of epistemology (the nature and origins of knowledge) through psychological methods, which he explored in Binet's psychometric laboratory in Paris. These three scientific fields contributed to the formulation of his theory.

Piaget's biological background is obvious in his basic definition of intelligence (see also *Intelligence*): "Every response, whether it be an act directed towards the outside world or an act internalized as thought, takes the form of an adaptation or, better, of a re-adaptation" (Piaget, 1950, p. 3). According to his definition, "adaptation must be described as an equilibrium between the action of the organism on the environment and vice versa" (Piaget, 1950, pp. 6–7). He, thus, defined intelligence as “the state of equilibrium towards which tend all the successive adaptations of a sensorimotor and cognitive nature, as well as all assimilatory and accommodatory interactions between the organism and the environment” (Piaget, 1950, p. 10). Through the construction, expansion, and integration of mental structures, the individual not only acts (mentally and behaviorally) following the principles of logic, but also becomes more and more able to accurately predict future events (Piaget, 1971).

Piaget’s epistemological interests are reflected in his proposition that human beings gradually construct a more refined, solid, and logically robust representation of the inner and outer worlds (Piaget, 1977). The epistemological background of his theory is present in the concepts that are important in the philosophy of knowledge. Reasoning and logic, and the basic categories of reason, such as quality, quantity, causality, space, and time, were the subjects of his research for decades (Piaget, 1928, 1929/1979, 1930, 1952a; Piaget & Inhelder, 1956). A reader familiar with epistemology will be able to identify Kant’s categories of reason in Piaget’s thought.

Finally, Piaget’s psychological background is reflected in the introduction of his unique clinical method. When he was testing his theory by administrating carefully designed tasks, Piaget was interested not only in the correctness of the answers but, more importantly, in the reasoning that had led to the specific answer. In this way, his theory was cross-validated, since the reasoning level would place the individual in one of the proposed stages of development.

1. From Concrete to Formal Thought

It may be argued that the attainment of Piagetian formal thought, between 12 and 15 years of age, surpasses the accomplishments, and also the limitations, of the previous stage, that is, concrete thought, which is attained between 7 and 11 years of age. Both concrete and formal thought are operational, as opposed to the earlier Piagetian stages. The sensorimotor stage and the preoperational stage of thought involve representations but not integrated mental operations. An operation is a type of action or manipulation, applied either physically to objects or internally to categories or propositions (as in the case of formal logic). Put another way, an operation is a means that facilitates problem solving through the organization and selective use of mentally transformed data about the world. There is a crucial difference between a simple action and an operation in that the latter is an internalized, reversible action, which is bound up with other operations in an integrated structure.

According to Piaget, during concrete thought (Piaget, 1952b, 1954; Piaget & Inhelder, 1969) two types of transformations are present. The first, inversion, is the understanding that a transformation is reversible when it produces complete compensation. For example, the child realizes that changes in one dimension are counterbalanced by changes in another dimension. In terms of structure, a transformation is reversible when its reverse results in its cancellation. For example, the child realizes that a change may be canceled out by actually or mentally reversing the steps and returning to the original state. In this case, the child realizes that the product of a direct operation (e.g., adding) and its inverse operation (e.g., subtracting what was added before) is nil (0).

The second transformation, reciprocity, is focused on identity. For example, a child in the stage of concrete thought, when asked to put rods in order of increasing size, first chooses the smallest one, then the smallest of the ones left, and so on. These choices show that the child knows that a rod is at the same time smaller than those not yet placed in the arrangement (i.e., descending seriation, from the biggest to the smallest) and bigger than the ones that have already been arranged (i.e., ascending seriation, from the smallest to the biggest). Thus, a reversible composition of the relation smaller than and bigger than is present in the child's thought. The composition of these reversible relations allows the child to conclude that A is bigger than C (without being shown these two rods together) if shown that "A is bigger than B" and "B is bigger than C."

A composition of reversible actions is observed during concrete thought in class-inclusion tests. Here, the presence of a mental structure that groups various inferences related to the data is observed. In concrete thought, the child can compose the operation A + A<prime> = B (e.g., both roses and daisies are flowers) with the operation B − A<prime> = A (the number of roses is what is left after subtracting the number of daisies from the total number of flowers).

What, then, is the difference between the stages of concrete and formal thought? According to Piaget, the answer lies on the difference in the structural integration between concrete and formal operations: “the range of available operations can be described in terms of a limited number of interdependent structures. The structures found and the way in which they are integrated depends on the stage of development considered; each set of structures can be related to a particular group of logical forms” (Inhelder & Piaget, 1955/1958, p. xiv, emphasis original). During the concrete stage, operations are based on a grouping structure, depending on the logic of classes (for class-inclusion operations, based on the form of reversibility of inversion or negation) and the logic of relations (for serial ordering, based on the form of reversibility or reciprocity).

Thus, although inversion and reciprocity are present during concrete thought, there is no general structure to integrate transformations by inversion and transformations by reciprocity into a single system. This system emerges in the logic of the adolescent, which shows that the two forms of concrete operational reversibility are coordinated into a single system, that is, the inversion of the reciprocal or the reciprocation of the inverse. Here the original identity or the reciprocal interrelations of an object (or category or proportion) can be inversed or an inversed object (or category or proportion) can acquire a different identity (or can be characterized by different reciprocal interrelations).

Attainment of the above structure leads to the realization that (1) the apparent properties of a specific object (category or proposition) is just one tangible combination of its inherent properties, among other (real or imagined) equally probable combinatory versions of the same properties; (2) it is possible to grasp all the instances that may result from the combinations of the absence and/or the presence of these inherent properties; (3) in this way, any object (category and proposition), stripped from its real physical properties, may then be conceived as an abstract entity; and (4) finally, it is possible to combine these abstract entities so as to construct mental/abstract realities which can still be imagined, regardless of whether or not they can possibly exist.

Thus, whereas concrete operations provide the means for structuring the immediately present reality, formal thought leads to the conception of both the real and the possible. In accordance with this, during the formal stage, the adolescent's logic becomes propositional. Thus, another striking difference between concrete and formal operations, apart from the integration of operations, is that the latter are performed on propositions (i.e., statements referring to reality) rather than directly on reality (Inhelder & Piaget, 1955/1958).

The propositions on which formal operations are performed are conceived by the adolescent as variables, which are hypothesized to be either the cause or the result of changes in the (inner or outer) environment. In this way, formal thought results in a segmentation of reality into continuously transformed propositions (e.g., in the form "if…, then…"). Also, during formal thought, the adolescent can consider simultaneously more than one single relation or variable at a time.

But, as stated by Inhelder and Piaget (1955/1958, p. xxii), "formal thought is more than verbal reasoning, or else, propositional logic. It also entails a series of operational schemata which appear along with it; these include combinatorial operations, propositions, double systems of reference, a schema of mechanical equilibrium (equality between action and reaction), multiplicative probabilities, correlations, etc." Thus, according to the authors, any reference only to the specific operations of propositional logic is not sufficient for understanding the development of formal thought. In the general Piagetian view of development, integration is a key concept for fully understanding the transition between stages. In the case of the transition from concrete to formal thought, Piaget refers to "integrated structures" on which the specific operations of propositional logic are based, and specifically their integration into a combinatorial system or a structured whole (Inhelder & Piaget, 1955/1958).

The structured whole has the following properties: (1) It allows composition, that is, not only the assimilation of the facts in the form of propositions but, more importantly, their arrangement according to all the possible combinations. (2) By applying reversibility and complete compensation, the adolescent is able to create successive situations where each possible explanation, which has already been constructed and held in mind, is then systematically checked for its truth or fallacy. Thus, according to Piaget (Inhelder & Piaget, 1955/1958), the development of formal thought is simultaneously moving toward a construction of wholes (i.e., integration of the parts or elements through composition) and a finer and detailed discrimination of the parts that comprise the whole (i.e., apart from being integrated, the parts are clearly separable from each other, through reversibility and compensation).

An example that illustrates this is when children are shown several rods of different lengths, thicknesses, and materials, and are asked to propose a pair of rods that would constitute a fair test of the hypothesis “Long rods bend more than short rods.” During the stage of concrete thought, a child would test pairs of rods of different length and, by trial and error, find a pair of rods, regardless of their material or thickness, that would certify the hypothesis. In contrast, a formal thinker, who would be able to think propositionally and abstractly, would realize that if, ideally, there were two rods that differ only in their length then their comparison would lead to the undeniable conclusion that flexibility can be ascribed only to length. But, in reality, rods have more properties than just their length (e.g., material).

The next possible mental act that would assimilate or resemble these ideal, imagined rods would be to negate or cancel out all the other properties of the rods. Thus, all possible variables are checked and are either rejected or accepted as logical causes of the effect observed. As already mentioned, Piaget (Inhelder & Piaget, 1955/1958) believed that this type of reasoning, whereby all relevant dimensions are tested through successive, systematic trials by keeping stable all others except the one that is being manipulated in order to ascertain its possible causal role, can be achieved only if inversion and reciprocity are integrated to such an extent that the thinker can understand their equivalence.

Therefore, an adolescent or an adult, faced with a cause–effect problem, would first come up with a model where all possible variations are included, thus taking into consideration a priori the length of the rods, their material (e.g., wood, steel, or plastic), and their thickness. That is, all propositions (or possible explanations) are already internally stated and combined, before the actual testing of the hypotheses takes place. In the statement posed ("Long rods bend more than short rods"), the only way to negate and cancel out the effects of the other properties would be to make them the same, thereby still affecting flexibility but to the same degree (e.g., comparing two rods made of the same material and of the same thickness, differing only in length). Only by controlling for these intervening properties can any observed difference in the flexibility of the rods be attributed to their differences in length.

Formal thinkers, though, would not stop their experimentation at this point. Since the propositional operations function as a whole, which is internally structured, they would elaborate more on the question as to whether flexibility can be ascribed only to length. They would proceed with controlling whether the material (e.g., wood or steel) affects the flexibility, controlling, this time, for length and thickness, or whether the thickness exerts any effect, controlling for length and material. The end product would be a synthesis where all properties and their combinations are tested, and the conclusion would reflect the systematicity with which all properties were controlled for (e.g., "It is true that longer rods bend more easily than shorter rods, provided that they are equally thick and made of the same material, but also that steel rods bend more easily than wooden rods of the same length and thickness").

2. Characteristics of Formal Thought

All specific characteristics of formal thought derive from the propositional logic, the structured whole, and the integration of inversion and reciprocity into an integrated system. Five main abilities emerge from the attainment of these:

- A formal thinker has the ability to conceive both the possible and the real, for example, “What if there were rods whose only property would be length and nothing else?” On the contrary, a concretely thinking child conceives the real and works toward the possible.

- Formal thought is hypothetico-deductive. An adolescent becomes capable of forming hypotheses that would explain cause–effect relations and also of deducing their truth. On the contrary, a concretely thinking child, although able to form hypotheses based on reality, lacks the ability to design experimentation that would lead them to complete deductions.

- Formal thought is combinatory. This enables the construction of mental models that control all possible variables and their combination as causes and then, through the control-of-variables strategy, to the extraction of valid conclusions. A concretely thinking child does not seem to be able to conceive of all the possible combinations and their experimentation is random and incomplete.

- A formal thinker can discriminate between the robustness of a conclusion and the reality per se. Where the premises do not coincide with reality, they can decide on the validity of the conclusion, based on the application of logical rules. A child, however, is still bound to reality and will thus reject valid conclusions in case they derive from invalid premises.

- The formal stage involves reflective thinking. Adolescents are capable of thinking about their thoughts and ideas, critically analyzing them, and systematizing them in a deliberate construction of theories.

3. Universality of Formal Thought

Piaget (Inhelder & Piaget, 1955/1958) believed that formal thought was the last stage of equilibrium, preparing the adolescent to efficiently enter and to adapt to the adult world. There is no doubt that human development, as conceived by Piaget, was very influential. There is also no doubt that the experiments he designed were appropriate for capturing the transformation of thought and the transitions from one stage to the next. Despite the recognition that Piaget's theory received, some serious doubts were raised, grounded in robust empirical data, about the universal attainment of formal thought. When Piagetian experimental testing for the acquisition of formal thought were replicated, the results were disappointing, in that more than half of the population of adolescents and adults failed to operate as formal thinkers. In addition, formal reasoning did not appear to be a generalized ability in all subject areas (Markovits & Barrouillet, 2002), and, although application of formal operations was not spontaneous for some participants, appropriate questions or probing led them to exhibit formal thinking (Stone & Day, 1978), or their performance was advanced when people were collaborating within groups rather than working individually (Dimant & Bearison, 1991).

An explanation for these data may derive from Piaget's background as a biologist, an epistemologist, and a clinician. Perhaps his biological background misled him in terms of the generalizability of formal operations. Piaget conceived of intelligence as an adaptation mechanism, which, once attained, is bound to be applied to every aspect of an individual's environment. Although Piaget was aware that in concrete thought the attained operations were not applied in perfect synchronicity (i.e., they show a decalage, or time lag, in attainment), the overall picture was that gradually the concrete operations would be steadily used across all domains. Furthermore, given that his data robustly verified the expected shift to all the previous stages he had conceived (from sensorimotor to preoperational to concrete thought), it seems perfectly logical and consistent to have assumed that the upcoming shift from concrete to formal thought would also apply to all individuals.

As stated later by Piaget himself (1972), and as confirmed by the cross-validation of his view, formal thought is definitely not a generally applicable way of thinking, but is bound to certain areas of expertise. In this way, the same person may spontaneously answer as a formal thinker when deciphering relations in a certain domain of thought but as a concrete thinker in another domain, where his or her accumulated knowledge and expertise is limited. This is an interesting finding, which goes far beyond the actual intraindividual differentiation of performance. It contributes to the mainstream question about the unity and/or the modularity of the mind, not only on the level of performance (Karmiloff-Smith, 1995) but on the neuropsychological level (for an overview, see Demetriou & Spanoudis, 2018). The finding is also relevant to the observed interindividual differences in cognitive development, an area that was not elaborated in the Piagetian theory.

In addition, the area of expertise may not be necessarily related to formal schooling or education. This connects to the second dimension of Piaget's background, the epistemological one. Piaget's theory was greatly influenced by the Kantian concepts of reasoning and logic and the basic categories of reason such as quality, quantity, causality, space, and time. Here a gap appears between science and real life. It seems that the "Piagetian human being" and the adult world that Piaget conceived were almost purely scientific. But is this the case in the real world? The answer is definitely no. Given that, it is not a surprise that an individual may fail to apply formal operations, when tested with experiments that are inspired mainly by the world of science. Familiarity, thus, would play an enormous role in the quality of the answers given by the participants. In accordance, there are numerous studies (coming especially from the conceptual change paradigm) showing that the acquisition of any scientific knowledge is a slow process, characterized by conflicts and misconceptions (see Vosniadou, 2013, for further elaboration). It has also been shown that analytic thinking and the application of appropriate strategies may not be attributed to age or growing per se, but mostly to the systematic and long-term teaching of the scientific knowledge. From this angle, the conflicting results on the universality of the formal thought may be more easily interpreted, bearing in mind interindividual differences in familiarity with the testing context, the amount of teaching, the accumulation of relevant knowledge, and, most importantly, differentiation between real life and science.

The third dimension concerns the clinical methodology that Piaget adopted. Piaget was interested in the spontaneous intelligence of the child and the adolescent. This method was fascinating because it permitted a robust validation of his theory, by allowing the individual to unfold the operations that they apply. However, two reservations emerge: Were the participants motivated enough to try their best during testing? And why was the possible difference between spontaneous answers and answers produced after appropriate probing not of any value to Piaget? As far as motivation is concerned, there is no doubt that methodology plays a crucial role in the quality of the answers provided by participants. When someone is not interested in the setting of an experimental condition, finds no value in engaging with it, or, even worse, is repulsed by it, it is more than certain that there will be a remarkable divergence between attained and observed performance.

As far as probing is concerned, focusing on the spontaneous answers has its own merit, but it also leads to two equally interesting questions. The first is: Given that the application of formal operations can be probed, is it also possible that formal thought can be taught at an earlier age than that stated by Piaget? Answers to this question are contradictory. Yes, it can be taught but not completely or efficiently enough, since taught formal operations cannot be generalized to other domains than the ones in which training took place. The second question is: How logical are we as human beings in real-life conditions? In his lab, Piaget did not help his participants to perform at their optimum level, and this tactic certainly led to an underestimation of their cognitive abilities. But, even if he would, would that change how people think, act, and make decisions in their everyday life? For example, when a person is faced with a personal dilemma, the chances are that they would not be helped (or be willing to be helped) to make the best possible choice by someone who has already attained the formal level of reasoning. Thus, probing would have been (and is) extremely informative on a theoretical level but, given that Piaget's main focus was on the equilibrium between the individual and their environment, it makes perfect sense that he did not allow for any kind of probing when designing or administrating his tasks for children and adolescents.

3. Conclusions

Piaget conceived of development as a process of four distinct qualitative stages. He attributed cognitive change to the mechanisms of assimilation, accommodation, and equilibrium, and to the integration of mental operations into organized structures that differ at every consecutive stage in their complexity and their efficiency at minimizing the conflicts between already acquired knowledge and the situations at hand. He claimed that the attainment of abilities developed in each stage was universal and holistic (with the exception of formal thought, which maintained its universality but was constrained by individuals' areas of expertise).

In addition, Piaget focused on the development of logical mathematical thought, and of specific areas of reasoning (such as causality, time, and space). Furthermore, he introduced a clinical method to reveal the child's stage of reasoning. Finally, he conceived of intelligence as the human's tool for adaptation and considered formal thought to be the last stage in human development which would ensure that no more disturbances would be encountered in our adaptation to the adult world and that equilibrium would henceforth be stabilized.

Hundreds of thousands of pages have been written on each of these propositions, either in favor of or criticizing the Piagetian view of development. For example, the very existence of stages is greatly disputed. The mechanisms of cognitive change proposed by Piaget have also been an area of controversy, with scholars from different traditions proposing alternative stages and/or mechanisms of cognitive development, and emphasizing, for example, the attainment of appropriate strategies in reasoning and problem solving, conceptual changes, or the development of core cognitive abilities, such as speed of processing, executive functions (see *Executive Functioning in Children*), and memory (see *Working Memory Development*). Another area of dispute concerns the adequacy of the Piagetian holistic mechanisms of cognitive change to explain the whole range of human development, especially intra- and interindividual differences (see also Siegler & Alibali, 2005).

The Piagetian methodological clinical approach has also been received with skepticism. It has been shown that, as a method, it could not always reveal the participant's actual reasoning abilities, since intervening factors (such as familiarity, memory span, motivation, misinterpretation of the requirements of the tasks) often led to an underestimation of the participant's performance (as in Sinnott, 1975).

Furthermore, conceiving of the infant, the child, and the adolescent as potential experimenters, with the end product being the attainment of a logical–mathematical mind, has also been greatly disputed, because performance in real-life settings may differ substantially from that in experimental settings.

Accordingly, a number of theorists have claimed that the strict logical reasoning of an adolescent, in reality, may lead to maladaptation rather than adaptation. Whereas for a scientist the attainment of a strict methodological approach is a prerequisite, adaptive functioning as a member of a society requires flexibility and recognition that there are situations where, by the very nature of our interactions with others in various social settings, there are not "right" or "wrong" conclusions, as there are in strict experimentation. Most of the situations we are dealing with are multivariate and conflicting, so that we have to gradually admit that nothing around us is either black or white, an acceptance that leads us to the acquisition of postformal thought. Postformal thought entails the conclusion that, in reality, we are constantly solving problems within a gray area, where our decisions are best made when balancing costs and benefits (see Labouvie-Vief, 2006). Another stream of research posits that humans continue to develop cognitively throughout the lifespan (e.g., Moshman, 1998; Schaie, 1978; see also *Transition from Adolescence to Emerging Adulthood*).

These points do not, in any way, undermine the great contribution of Piaget. Even if developmental psychologists disagree with some or with all of the Piagetian postulates, they would have to agree that Piagetian theory was one of the most influential theories in the history of science, providing an initial ground for the formulation of the theories to come. As a final note, Piaget continued to influence the course of developmental psychology, as the ancestor of a prominent group of neo-Piagetian theorists (such as Case, 1992; Demetriou, Shayer, & Efklides, 1992;

Demetriou & Spanoudis, 2018; Fischer, 1980; Halford, 1993; Pascual-Leone, 1970).

SEE ALSO: Intelligence; Piaget's Theory; Studying Cognitive Development in School-Aged Children; Theories of Adolescent Development: Overview; Transition From Adolescence to Emerging Adulthood

References

Case, R. (1992). *The mind's staircase: Exploring the conceptual underpinnings of children's thought and knowledge*. Hillsdale, NJ: Erlbaum.

Demetriou, A., Shayer, M., & Efklides, A. (1992). *Neo-Piagetian theories of cognitive development: Implications and applications to education*. London, UK: Routledge.

Demetriou, A., & Spanoudis, G. (2018). *Growing minds: A developmental theory of intelligence, brain, and education*. London, UK: Routledge.

Dimant, R. J., & Bearison, D. J. (1991). Development of formal reasoning during successive peer interactions. *Developmental Psychology, 27,* 277–284. doi:10.1037/0012-1649.27.2.277

Fischer, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review, 87,* 477–531. doi:10.1037/0033-295X.87.6.477

Halford, G. S. (1993). *Children's understanding: The development of mental models*. Hillsdale, NJ: Erlbaum.

Inhelder, B., & Piaget, J. (1955/1958). *The growth of logical thinking from childhood to adolescence: An essay on the construction of formal operational structures*. New York, NY: Basic Books.

Karmiloff-Smith, A. (1995). *Beyond modularity: A developmental perspective on cognitive science*. Cambridge, MA: MIT Press.

Labouvie-Vief, G. (2006). Emerging structures of adult thought. In J. J. Arnett & J. L. Tanner (Eds.), *Emerging adults in America: Coming of age in the 21st century* (pp. 59–84). Washington, DC: American Psychological Association. doi:10.1037/11381-003

Markovits, H., & Barrouillet, P. (2002). The development of conditional reasoning: A mental model account. *Developmental Review, 22,* 5–36. doi:10.1006/drev.2000.0533

Moshman, D. (1998). Cognitive development beyond childhood. In W. Damon (Series Ed.) & D. Kuhn & R. S. Siegler (Eds.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (5th ed., pp. 947–978). New York, NY: Wiley.

Pascual-Leone, J. (1970). A mathematical model for the transition rule in Piaget's developmental stages. *Acta Psychologica, 32,* 301–345. doi:10.1016/0001-6918 (70)90108-3

Piaget, J. (1928). *Judgment and reasoning in the child.* London, UK: Routledge & Kegan Paul.

Piaget, J. (1929/1979). *The child's conception of the world.* New York, NY: Harcourt, Brace.

Piaget, J. (1930). *The child's conception of physical causality.* New York, NY: Harcourt, Brace.

Piaget, J. (1950). *The psychology of intelligence.* London, UK: Routledge & Kegan Paul.

Piaget, J. (1952a). *The child's conception of number.* London, UK: Routledge & Kegan Paul.

Piaget, J. (1952b). *The origins of intelligence in children.* New York, NY: International Universities Press.

Piaget, J. (1954). *The construction of reality in the child.* New York, NY: Basic Books.

Piaget, J. (1971). *Biology and knowledge: An essay on the relations between organic* *regulations and cognitive processes*. Chicago, IL: University of Chicago Press.

Piaget, J. (1972). Intellectual evolution from adolescence to adulthood. *Human Development, 15*, 1–12. doi:10.1159/000271225

Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures.* New York, NY: Viking Press.

Piaget, J., & Inhelder, B. (1956). *The child's conception of space.* London, UK: Routledge & Kegan Paul.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child.* New York, NY: Basic Books.

Schaie, K. W. (1978). Toward a stage theory of adult cognitive development. *International Journal of Aging and Human Development, 8,* 129–138. doi:10.2190/1TEA-M6PK-28A0-49HV

Siegler, R. S., & Alibali, M. W. (2005). *Children's thinking* (4th ed.). Englewood Cliffs, NJ: Prentice Hall.

Sinnott, J. D. (1975). Everyday thinking and Piagetian operativity in adults. *Human Development, 18,* 430–443. doi:10.1159/000271504

Stone, C. A., & Day, M. C. (1978). Levels of availability of a formal operational strategy. *Child Development, 49,* 1054–1065. doi:10.2307/1128745

Vosniadou, S. (2013). Conceptual change in learning and instruction: The framework theory approach. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (2nd ed., pp. 11–30). New York, NY: Routledge.

Further Reading

Demetriou, A., & Spanoudis, G. (2018). *Growing minds: A developmental theory of intelligence, brain, and education.* London, UK: Routledge.

Flavell, J. H. (1963). *The developmental psychology of Jean Piaget*. New York, NY: Van Nostrand.

Piaget, J. (1950). *The psychology of intelligence*. London, UK: Routledge & Kegan Paul.

Piaget, J. (1970). Piaget's theory. In P. H. Mussen (Ed.), *Carmichael's handbook of child psychology* (pp. 703–732). New York, NY: Wiley.