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ABSTRACT

The development of cognitive representation is the main theme of three classic theories (Piaget, Bruner, Vygotsky) on how children learn concepts. Piaget considered structural change as a necessary condition for development; Bruner emphasized both internal and external function and the structural changes brought about by function; and Vygotsky stressed the reciprocal relationship between structure and function. While these theories converge to some degree with respect to effectively influencing the development of cognitive representation, they do not agree on evaluation standards for training effectiveness. Piaget and Galperin, a student of Vygotsky, would contend that it is only when stringent criteria for evaluating training effects are met (such as when the child can solve a wide range of transfer problems after training), and when the training results are durable, that one can conclude that the child's representation has changed. Many American training studies deal with specific training effects with only minor transfer and do not investigate the duration of the effect, making it impossible to conclude that representation changes through training. However, replications of long-term training studies using Obuchova's (1966) method--which maintains the same criteria used by Piaget--have shown that cognitive representation does change. The outcomes of training studies conducted by different theoretical schools clarify that one can examine only whether and to what extent cognitive representation is changed when stringent criteria are used to assess the effect of learning. (Contains 55 references.) (Author/KDFB)

Three Theories of Cognitive Representation and Their Evaluation Standards of Training Effects

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Running Head: Influencing Cognitive Representation

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Abstract

The development of cognitive representation is the main theme of the three classic theories on how children learn new concepts (Piaget, Bruner, Vygotsky). However, these theories do not agree on evaluation standards for training effectiveness. According to Piaget, it is only when stringent criteria for evaluating training effects are met, i.e. when the child can solve a wide range of transfer problems after training, and when the results of training are durable, that one can conclude that the child's representation has changed. Many American training studies deal with rather specific training effects with only minor transfer. Moreover, these studies do not investigate the duration of the effect, making it impossible to conclude that representation changes through training. The training method developed by Obuchova (1966) maintains the same criteria used by Piaget. Replications of training studies using Obuchova's method have shown that cognitive representation does change. The outcomes of training studies conducted by different theoretical schools clarify that one can only examine whether and to what extent cognitive representation is changed when stringent criteria are used to assess the effect of training.

Three Theories of Cognitive Representation and Their Evaluation Standards of Training Effects

In the literature of psychology, the entire range of processes involved in acquiring and understanding knowledge and the actions that proceed from knowledge is referred to by the term "cognition." Cognition resides at the mental level and is therefore not directly observable. We cannot establish through direct observation which operations an eight-year-old carries out to solve the arithmetic problem 96 - 29 = ? Cognitive psychologists study the underlying mechanism of the solution: the processes and skills that lead to a certain achievement. They are mainly concerned with the way in which the information has been represented, organized and transformed to direct the action of an individual; what this individual actually knows (knowledge database) is often of lesser importance. If a child initially solves only three arithmetic problems during a lesson, but later increases the number of correct solutions to twenty, it is not the increase in and of itself that interests cognitive psychologists. More important in their view is why the child ultimately succeeded in solving the problems more quickly and correctly. The answer might lie in the child's having discovered a solution strategy, or in his having developed an efficient algorithm.

Cognition concerns not only conscious activity, such as solving a problem, but also the unconscious activities and actions that we perform routinely in daily life without giving them much thought. Often we are not aware of the mental activity required to recognize a song on the radio, read a book, or tie our shoelaces. We perform many of these activities more or less automatically, even though complex mechanisms play an important role in these performances.

Cognitive development refers to the changes that an individual's mental apparatus undergoes due to experiences during his or her life cycle. One can distinguish between cognitive structure and function. Cognitive structure is a hypothetical mental construct that may change suddenly or gradually throughout development. One may assume that some type of mental organization makes it possible for young children to arrange objects in order of increasing length. If the differences in length are minimal, for example 2 mm, then a four-year-old will not yet be able to construct such a series correctly, although he would if the size differences were greater, for example if he were asked to build a tower of nested cubes. Once a certain change has taken place in the child's cognitive structure that makes it possible for him to focus on the most important details, he will have no difficulty constructing a series by placing objects that scarcely differ in size in ascending order.

Function concerns the internal and external actions related to the structure. Activating a cognitive process is an example of an internal action. In attempting to recall something, we are activating a series of internal actions that retrieve that particular word or concept from memory. Experience is the external aspect of function: it is the external source of stimulation.

From a structuralist point of view, development is often viewed as the interaction between structure and function. Activities that take place both in the environment and in the structure itself can contribute to changes in the structure, which in turn bring about changes in the way the structure operates. Although different theories concerning cognitive development have many aspects in common, what distinguishes them most is how differently they view the relationship between function and structure. Researchers whose orientation tends toward nativism support the view that development is dictated by the unfolding of genetically determined sequences upon which environmental factors have no effect. According to this view structure determines function. An opposing theory, which leans more toward behaviorism, states that experience is directly responsible for structural changes. In this view, function determines structural change. A compromise position between these two extreme theories of cognitive development holds that the activities performed by mental structures can force structural change (Bjorklund, 1988). The individual's own activity is the basic starting point for structural change.

The main purpose of this article is to review three mainstream theories of cognitive representation. The first theory was developed by the Swiss researcher Piaget, who considered structural change as a necessary condition for development. The second was developed by the American researcher Bruner, who emphasized both the internal and external functions as well as the structural changes brought about by function. The final theory to be discussed was developed by the Russian researcher Vygotsky, who also stresses the reciprocal relationship between structure and function. His theory was worked out in greater detail by Gal'perin and others.

Second, the article will describe that the three theories converge to some degree with respect to effectively influencing the development of cognitive representation.

Third, the article looks at training experiments conducted by researchers from the different theoretical schools aimed at affecting cognitive representation. By using the concept of transfer, the article shows that the three theories disagree as to the question when it can be assumed that a child's cognitive representation has changed. Although the three theories propose different standards for evaluating transfer in training experiments, they appear to converge when it comes to exercising a positive influence on cognitive representation, an approach that has proven useful in education.

Three Theories of Cognitive Representation

Piaget's Theory of the Development of Cognitive Structures

The work of Piaget (1896-1980) exerted a greater influence on developmental psychology than any other theory (Verhofstadt-Deneve & Vijt, 1989; Loth, 1989). In the following we will describe a few aspects of Piaget's theory in brief.

According to Piaget, cognitive development takes place in a sequence of discrete phases. A child's way of thinking in one particular phase is qualitatively different than in the previous or subsequent phases. Piaget does not view cognitive development as a gradual accumulation of knowledge or skills, but rather as a sequence of structural transformations: rather abrupt, intermittent changes in the way a child thinks. During the transition between two phases, the child inhabits two qualitatively different worlds. The discrepancy between what things seem to be and what they really are leads to a conflict in the child's way of thinking. A young child will judge a small object to be lighter than a large object. Later the child's experiences with objects, such as lifting them, will lead him to reflect on their characteristics. If the child then realizes that the weight of an object is determined not only by its size, but also by the material it is made of, then according to Piagetian theory he has undergone a structural change. His thinking has progressed to a new and higher level and has now become qualitatively different from his thinking based on the previous structure.

According to Piaget, cognitive development is a genesis of structures. Cognition develops by refining and transforming mental structures (Piaget, 1963, 1964a, 1964b, 1973). Structure as defined by Piaget means an organized totality within which the relationships between elements are clearly defined. Cognitive structures refer to mental knowledge and production systems that are not directly observable but that lie at the basis of intelligent actions. In simplified form, a structure can be seen as a type of knowledge database that a child uses to interpret the world. The child knows the world or observes reality in terms of its structures. Piaget attempts to describe and explain cognitive development by postulating general abstract structures in which seemingly different intelligent actions might be arranged. Brainerd (1978a) uses an apt analogy borrowed from linguistics to explain precisely what Piaget means by such general abstract structures. Consider the following four, brief sentences: "Pete teases Carl," "Wilma kisses John," "Hank kicks William," "Ann adores Frank." Each of the four sentences proposes something different or has a different observable concrete structure. Nonetheless, each of these four sentences is based on a single general abstract structure: subject, predicate (present-tense verb, third person singular), and direct object. This level of abstraction also characterizes the structures that Piaget claims lie at the basis of intelligent action.

Successive structures therefore differ qualitatively throughout the course of cognitive development. When a toddler grasps a block, he is performing a qualitatively different action than the elementary school child who understands an arithmetic problem. Piaget sees these different behaviors as representing the distinct structures. A common question is why Piaget identifies a baby's grasp as a structure. The more noncognitive structures that develop in the first year of life, sometimes known as schemata - the grasp schema and the suckling schema - are based on innate reflexes. Slowly these reflex movements become differentiated as the infant practices variations. In the course of time, grasping an object shifts from being a reflex to being a goal-oriented action. Such noncognitive structures are the precursors of the cognitive structures that follow (Piaget, 1975a, 1975b). At approximately 18 months, when a child begins to use symbols, he is taking the first step toward conscious activities that will lead to the construction of cognitive structures. Once established, a given structure will continue to exist or, if possible, will develop further. For example, grasping an object in thought can be considered a differentiation of the grasp schema in infancy. Cognitive development begins as a schema or structure; later this structure changes, producing a new structure at a level higher and therefore qualitatively different than the previous one, as demonstrated in the example given above.

A second aspect of Piaget's theory is the notion that the activity of children is intrinsic. Their structures are intrinsically active, intrinsically curious. Children are not satisfied with what they already know, but are constantly in search of greater knowledge. The motivation to develop is generated from within. Although Piaget acknowledges that environmental and biological factors play a role, he considers intrinsic activity the motor of cognitive development. The fuel for this motor is the reciprocal relationship between function and structure, namely that the child's activity, or in reality the activity of the structures, influences the subsequent development of these structures. Cognitive development results from the process of construction performed by the child. The child constructs his own reality. The child naturally interprets the information that reaches him from his surroundings in terms of the information he already possesses. Development means a change in both knowledge and ability. The database changes, and this produces a change in how the child perceives reality.

<u>Piaget's view of development and learning.</u>

According to Piaget (1975b), learning is in essence identical to acquiring a permanent qualitative change in the cognitive structure. Learning causes existing structures to become differentiated and coordinated. A new cognitive structure is the result of this process. Piaget's definition of learning is thus restricted, since not every learning experience leads to a change in the general structure. Piaget (1959a, 1959b) distinguishes two types of learning: learning in the strict sense (through simple or empirical abstraction) and learning in the broad sense (through reflective abstraction). By handling and manipulating objects, a child uncovers the features of these objects. He may, for example, determine that one object is heavier than another. These physical experiences are object-bound. The general feature that the child distils from these experiences is viewed at the level of empirical abstraction. While handling an object, the child perceives a distinguishing feature or characteristic, but that characteristic fades away as soon as the object is removed from his presence. His experiences do teach him something, but this new knowledge does not lead to a change in his cognitive structure. Learning in the strict sense of the word precedes learning in the broad sense. If the child reflects on the coordination of thought activities (operations), then abstraction is no longer linked to objects, but rather to the activities that he himself performs. Learning in the broad sense of the word leads to a reorganization of the cognitive structure. Mental reorganization at a higher level is grounded in the elaboration of abstractions at a lower level (Piaget, 1974, 1976). Learning in the broad sense by means of reflective abstraction is in reality the same as what the literature of developmental psychology calls "natural" development. According to Piaget, learning that does not take place by means of reflective abstraction will not bring about a new cognitive structure. In relation to this, Piaget points out that in many educational experiments that use reinforcement and feedback to teach concepts, for example, the child will at best acquire a command of empirical abstractions. Mastering these abstractions will not lead to a fundamental change in his cognitive structure, but at the very most to a substructure or isolated schema (Kingma & Koops, 1984c).

The development of knowledge as a function of learning in the broad sense is, according to Piaget, a spontaneous process related to the totality of cognitive structures. Because many educational experiments frequently limit learning to a single problem or structure, Piaget sees this as a limited process. Nevertheless, he does believe it possible to develop training methods which use learning to build successfully more complex cognitive structures from simpler ones in which the necessary relationships between integrated structures are created (Piaget, 1959). Socioeducational transmission is indeed of fundamental importance for learning, but it does not sufficiently explain learning itself. A child will only be able to master the valuable information he receives through socioeducational transmission if he understands this information. The child must first possess a cognitive structure in which he can assimilate this information.

> "This is why you cannot teach higher mathematics to a five-year-old. He does not yet have structures which enable him to understand" (Piaget, 1964b, p. 13).

<u>Bruner's Theory Concerning the Development of Cognitive</u>

Representation

Major age-related changes in behavior and thinking are largely the result of the acquisition of new, more flexible and more powerful types of representation. Bruner (1964, 1966a, 1966b, 1973, 1974) distinguishes three types of representation, the origin of which he claims is related to the developmental level of the child. The three forms or modes of representation are: the enactive mode (representation by doing), the iconic mode (representation by conception or spatial schema), and the symbolic mode (representation by means of description in language).

The first form of representation in cognitive development originates in the enactive mode; an object or event is understood, known or represented by the actions that have been performed with it. This form of representation originates during the first two years of life. This is to some extent comparable to Piaget's idea of the representation of actions in a motor schema. The grasp schema is a good example of an enactive representation. Children understand objects in terms of the actions which they can perform with them. A bicycle is there to be ridden, a ball to be played with, a spade to build a sand castle or dig a hole with. Another example which adults can also imagine is the answer to the question "How do you tie a shoelace?" It is difficult to express in language the essence of one's knowledge of how to do so. Nevertheless, we do know how to tie a shoelace; the necessary knowledge would appear to be stored in some kind of program which coordinates the muscles and the other systems responsible for eye-hand coordination. The question is whether enactive representation actually concerns mental representation (Daehler & Bukatko, 1985). After all, one could say that enactive representation is nothing more than a sequence of motor responses. According to Bruner, the coordination of the various behaviors requires a form of representation: the mental schema originates from the action and the sensory feedback.

A second form of representation which, according to Bruner, originates between the ages of 18-21 months, is iconic representation. In essence, iconic representation is the accessing of a mental representation in the form of images. Accessing a person's appearance or the features of a painting are familiar examples of accessing a mental representation of an image. These images are not, however, an identical representation or image of reality. Neither are they arbitrary representations, however. Certain perceptual characteristics of the object stand out more than others, and these as well as other aspects such as degree of interest or prior knowledge, determine what is fixed as a mental image. An important advantage of the iconic code as compared to the enactive is that the representations are now relatively independent of the action.

> "They are generally freed from the temporal and physical constraints of accompanying motor activity and can be constructed, examined, reordered, and organized. To be sure, this capacity may be fleeting and limited early in development. But it characterizes a powerful and significant new mental capacity, opening up opportunities for intellectual processes to operate at a new level, liberated from motor constraints. As a consequence, it becomes much easier to apply such terms as

thinking and reasoning to this type of representation" (Daehler & Bukatko, 1985, p. 5).

Bruner contrasts the more or less stimulus-dependent thinking of the iconic preoperational child with the more abstract language-based thinking of a child in the concrete operational phase. According to Bruner, language is not only used for communication but also provides a means of manipulating symbols. The power of language as a conceptual tool originates at approximately seven to eight years of age. According to Bruner, socioeducational transmission plays a highly significant role in this regard. Symbolic representation consists of codes with a linguistic or more abstract basis. Representation therefore does not require physical resemblance to reality. Mathematical symbols or the schematic representation of chemical compounds are familiar examples. The development of symbolic representation contributes to the child's no longer being restricted by sensory experience. Divorced from the experience, the child can reflect on the consequences of an action. Each form of representation continues to be available to the individual after it has been acquired. The various forms of representation can interact at any age, or can be combined to form more abstract codes of symbolic representation.

What Bruner emphasizes is the function of cognitive structure. The way this structure looks is not the focus of his research. The structure, however, is changed by the conflict between the various forms of representation. If this conflict is resolved, then both the structure and the code of representation are changed. For example, the difference between the appearance of an object and its actual identity is an important measure of the development of representation. An object takes on a different appearance when viewed from different perspectives (iconic images). When a child begins to realize that it is viewing the same object, even if the appearance differs, he experiences a conflict between the symbolic and the iconic code. The child is conscious of this conflict and will try to resolve it.

By reflecting, integrating new experiences or asking others (adults) for help, the child learns, by activating his verbal skills (labeling), to rely less on his own perception. At the moment that he does this, he resolves the conflict between the two forms of representation. The child will no longer be misled when an object seems to take on a different appearance (as in a conservation task), because he has acquired symbolic representation enough to know that he is dealing with the same object. For Bruner, cognitive development results from the continuous resolution of conflicts between the various modes of representation. He believes that cognitive development can in fact be stimulated by inducing conflicts between the various modes of representation.

Bruner's view of development and learning: Readiness to learn and learning through discovery.

According to Bruner, education should anticipate the actual cognitive level of the child. In this way, the child will advance to a higher level. Furthermore, it is interesting to the child to learn new, unfamiliar things. This vision contrasts sharply with Piaget's, in which education should go hand in hand with the actual cognitive level of the child.

With respect to instructional approach, Piaget and Bruner largely agree. Bruner, like Piaget, emphasizes that things sink in best if the child discovers them himself. The teacher plays a greater role in Bruner's approach to classroom education than in Piaget's, in which the teacher remains in the background and merely offers the child suitable material. According to Bruner, teachers ought to introduce problem situations that will stimulate children to such an extent that they try to discover the structure of the subject themselves. The term structure refers in this context to the framework of fundamental ideas, the relationships or general patterns of the subject, or to essential, basic information. Specific facts and details clearly have no role in such a general structure. Once self-discovery has led to the acquisition of an abstract structure, these facts can be fitted into that structure. Education should be set up in such a way that children learn to reason by induction. The method to be applied in this case involves formulating a general principle from examples and details. In learning through self-discovery, the teacher presents specific examples. The children work with these examples until they discover relationships and at the same time the structure of the subject. Learning to classify is a good example of the way in which children can formulate a general principle from details. For example, as a child arranges figures, circles, rectangles, or squares, he will discover the general principle that small and large circles belong to the category of circles, which in turn can be subdivided into two categories according to two characteristics. The general principle as applied to triangles may be as follows: triangles with unequal sides and isosceles triangles. Triangles with unequal or equal sides can be divided in turn into acute, obtuse or right triangles. Rectangles can be categorized as belonging to the class of quadrangles. Squares in turn are a type of rectangle.

Placing the terms in a coding system provides a better insight into the basic structure of geometry. The structure of this coding system consists of a hierarchy of related concepts or classes. At the top is the most general concept, "closed planimetrical figure." Lower down in the hierarchy the concept is specified further (see for example the location of the equilateral triangle). According to Bruner, if the child is given enough examples of the various planimetrical figures, he will eventually discover which qualities the different figures have. We might question whether this discovery is a completely spontaneous process. It is in part, but the teacher can guide children by encouraging them to reason inductively.

The key to success in the inductive approach is to encourage intuitive thinking, in other words, making a mental leap (representations) in order to achieve viable solutions or to correct previous perceptions. For example, children can be encouraged by making them guess a result on the basis of incomplete evidence and then by systematically proving whether these guesses are correct or not (Bruner, 1960). A teacher might approach a multiplication problem such as 145 x 155 by first asking the children to guess between which two numbers the solution will fall. A rough estimate would produce the answer: between 100 x 155 = 15500 and 200 x 155 = 31000. A more refined approach using mental arithmetic would produce the number: 100 x 155 + 50 x 15500 = 15500 + 7750 = 23250. Estimating the answer ahead of time or proving and checking the correctness of the estimate provides feedback on the method used to solve the problem. Feedback is a powerful means of stimulating transfer.

> "The students could check their guesses through systematic research. The research might prove more interesting than usual for students, since it is their own guesses that would be at stake. Unfortunately, educational practices often discourage intuitive thinking by punishing wrong guesses and rewarding safe but uncreative answers" (Woolfolk, 1987, p. 275).

In Bruner's "discovery learning" approach, children actively and independently work to discover the basic principles of a subject. The self-discovery method assumes that children have an intrinsic motivation to explore a subject independently. In the day-to-day practice of teaching, not all children are intrinsically motivated. That is why Bruner proposes to let the teacher guide children in a subject and set them on the path to discovery. In most situations, "guided discovery" is preferable, if only because practical considerations demand that a portion of the material be covered in a certain amount of time. In this manner the teacher can ask questions that excite the children, or present problems that awaken the interest of the children. "How would you classify these objects? Why does a piece of wood float in water? Why are so many plants green?" The teacher offers suitable material and encourages the children to make observations, formulate hypotheses or guess why such a thing will happen, for instance, and test the proposed solutions. The teacher poses specific questions that will put children on the trail of the right solution. In contrast to Piaget's approach, Bruner believes that a teacher should provide feedback concerning the solution or the proposed line of reasoning. This feedback must be offered at the right time, certainly at the moment that the student can use it to correct a given approach. Feedback can serve equally as an encouragement to continue using a given approach towards structuring the subject.

At first glance, Bruner's belief that we can influence cognitive development by inducing conflicts between modes of representation reflects an optimistic view of the degree of influence that socioeducational transfer has on such development. He is rather skeptical about rote learning; in his view, learning must be meaningful. By structuring a subject, either alone or under guidance, with the help of one coding system or another, a student is able to discover its general underlying principle. This general principle constitutes a form of symbolic representation (compare the coding system). The examples first given were initially still at the level of iconic representation (images). Learning to discover general principles influences the development of representation. It is precisely by presenting the student with new or unfamiliar subjects, in other words by anticipating the actual developmental level, that we can teach him new principles, thereby advancing representation concerning that subject to a higher level.

Vygotsky's Theory of Development of Cognitive Representation: The Action Psychology Approach

The psychology of action does not restrict the term action to mean that which is done with the hands alone; the term also includes thinking or mental action (Van Parreren, 1988). In this connection, the theory resembles Piaget's concept in which a (thought) operation represents an internalized action. It is important to note that the two theories clearly differ as to the role of language in the internalization of actions. Vygotsky (1962) proposes that language often serves to direct the intelligent actions of children. The relationship between language and thought undergoes a number of changes in the course of cognitive development. In the course of time, through the internalization of actions through language and speech, the representation of action is raised to a symbolic level.

Cognitive development is seen as a process in which a child receives from an adult the "cognitive cultural heritage" formed in the course of his society's history. Researchers whose orientation tends toward the psychology of action believe that cognitive development can be influenced by socioeducational transmission. Like Bruner, Vygotsky believes that education should anticipate development. It is not the task of education to keep pace with the child's actual developmental level, but rather to cover the region between the lower limit, what the child can do independently, and the upper limit, what he can do with the help of an adult (Van Parreren, 1979). Vygotsky (1962) calls the region between upper and lower limits the zone of proximal development.

> "...the zone of proximal development. It is the distance between the actual developmental level as determined by independent problem solving and the level of potential

development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86).

The actual developmental level is determined by functions that have already matured, according to Vygotsky. In other words, they are the end products of development up to that moment. The zone of proximal development contains those functions that are not yet ripe, but are still in a process of maturation.

"These functions could be termed the 'buds' or 'flowers' of development rather than the 'fruits' of development. The actual developmental level characterizes mental development retrospectively, while the zone of proximal development characterizes mental development prospectively" (Vygotsky, 1978, pp. 86-87)

Imagine two children, each at the mental age of eight years. With the help of an adult, one of the children is able to solve problems at the level of a nine-year-old, while with the same help the other learns to solve problems at the level of a twelve-year-old. The two children have the same mental age, based on their actual developmental level, but the potential developmental dynamics clearly differs. What a child can do with assistance in his zone of proximal development today, it can do independently tomorrow.

"Experience has shown that the child with the larger zone of proximal development will do much better in school. This measure gives us a more helpful clue than mental age does to the dynamics of intellectual development" (Vygotsky, 1962, p.

103).

How do we determine the zone of proximal development? In one approach we show a child how to solve a problem and see whether he is able to find a solution by imitating our example. Another example is to begin to solve a problem and ask the child to complete our work. A third tactic is to ask the child to solve problems meant for a higher mental age in cooperation with another, more developed child. Finally, we can explain the principles of the solution to the child, make suggestions in the form of questions, or divide the problem into subproblems (Van der Veer, 1985).

According to Vygotsky, many researchers determine the cognitive developmental level by giving the child test problems without offering him assistance, demonstrations or suggestions in the form of questions. What is in fact being determined is the actual level of imitation and of learning. Imitation also plays a role in the zone of proximal development. The scope of imitation can be illustrated by the following example. Let us assume that a child finds it difficult to solve a given arithmetic problem. If the teacher works out the problem on the blackboard, the child can suddenly understand the solution and imitate it in later assignments. If, however, the teacher demonstrates the solution to a more difficult arithmetic problem, the child will not be able to understand it regardless of the number of times he imitates the teacher's example. The actual cognitive level provides the tool which can be used in the zone of proximal development. Learning directed at the actual cognitive level (compare Piaget's view) is, according to Vygotsky, inefficient from the point of view of the child's general development.

> "It does not aim for a new stage of the development but rather lags behind this process. Thus, the notion of a zone of proximal development enables us to propound a new formula, namely that the only 'good learning' is that which is in advance of development" (Vygotsky, 1978, p. 89).

Learning in the zone of proximal development makes a necessary contribution to cognitive development. We should therefore not wait until the child is mature enough to handle the new concept to be taught; we should, rather, make use of education to bring the child to maturity, in other words make a contribution to its development such that it can indeed deal with the material. Van Parreren (1988) refers in this connection to "developmental education," (ontwikkelend onderwijs) meaning that it is unnecessary to wait until the child has reached the required level of development. Nor do we need to lag behind development; the point is to anticipate it. The extent to which development can be anticipated is dictated by the cognitive tools that the child possesses and the range of its zone of proximal development. Education which concerns itself with the zone of proximal development helps the child to advance: the child is able to make independent use of the new options. Even though Vygotsky emphasizes guiding cognitive development, he considers the child's own activity and the developmental tendencies resulting from it as important for cognitive development. Development comes both from within and from without (Van Parreren, 1988).

According to Vygotsky (1978, p. 89), the process of language acquisition provides a paradigm for the general problem of the relationship between learning and development. Initially, language originates as a means of communication between the child and those in his environment. Only later, after the conversion to inner speech, does the child's thinking become organized; in other words, it becomes an internal mental function. Essentially, we are dealing here with the development of symbolic representation. Thinking and speech therefore have different roots in cognitive development. These are at first independent: thinking is prelinguistic and speech is preintellectual. During the course of development, both are so converted that thinking becomes verbal and speech becomes rational. Language becomes not only the tool with which to think, but is also a system with which to represent the world.

Vygotsky's and his followers' views of development and learning: The stepwise formation of mental actions.

Students of Vygotsky - El'konin, Gal'perin - have instigated and carried out long-term educational projects. They have concerned themselves not only with the restructuring of primary education but also and in particular with demonstrating that cognitive development is to an important extent determined by what children learn (Van Parreren, 1979). Gal'perin's theory of the stepwise formation of mental actions has been a particularly fertile source of training studies (Kingma & Koops, 1988). In Gal'perin's views concerning the relationship between development and learning, we can recognize two important Vygotskian principles: that of the zone of proximal development and that of internalization (Van Parreren, 1979).

In the case of internalization, the assumption is that mental actions originate from material actions. Material action takes place when there is external intervention in concrete reality (the manipulation of objects); mental action takes place when this intervention is internal. Gal'perin has developed a method for the stepwise formation of mental actions. The child first acquires his own orientation toward carrying out the material action. The child learns to concentrate on the characteristics of the material, to deal with various types of material, and to determine which indications must be utilized with respect to a particular component of the action. The concern here is to give an overview of the preconditions for action and the components of the action as a whole. Gal'perin terms this whole the orientation basis for the action. The orientation basis must include everything necessary to carry out the action without error in any circumstance. The action is then carried out with concrete objects. The teacher can, for example, demonstrate an action to the child, after which the child carries it out independently. The child then describes the action in words, first with and then without the objects present. In the latter case, we are dealing with verbal actions. When the child is able to express the verbal action aloud without seeing the objects, then the action has taken place on a mental level. When this mental action has become automatic and therefore entirely natural, the action takes on an abbreviated form, and this abbreviated action becomes a component of inner speech. When an adult is asked : "What is 2 + 3 ?" he immediately responds "5."

He knows theoretically that the question concerns addition, but he no longer needs to carry it out.

According to Gal'perin, an essential step in cognitive development is the mastery of a rational object schema (Van Parreren, 1979). By rational object schema he means a rational structure that we project onto observable things and which we use to compare objects quantitatively. Without this rational object schema, a child considers an object a perceivable unity, in which one particular feature dominates. The child can only compare objects qualitatively. He perceives a characteristic of the object through observation and by implication believes that the object is long, thick or heavy. Once the child has mastered the rational object schema, however, then according to Van Parreren (1979) his perception has undergone three changes. First, he sees an object as a bundle of characteristics, such as shape, color, length, weight, and volume. These characteristics are independent from one another or have certain mutual relationships, but each is an independent quantity. Second, he sees each characteristic of an object as a quantity comprised of units; for example, length can be measured with matchsticks. The third change is that the child can place a collection of units into order by applying a general rule (one object is two matchsticks long, the other three). Using the rational object schema makes it possible to compare objects quantitatively. According to Gal'perin (1966, 1972), the reason why young children are not able to perform Piagetian tasks (seriation, classification, conservation, and the like) is that they have not yet mastered the rational object schema. Even though schools do not systematically teach the rational object schema as proposed by Gal'perin, in general children of approximately seven to eight years are capable of solving Piagetian problems correctly for the most part. Gal'perin attributes this phenomenon to the experiences that a child has in daily life. These experiences, however, are not systematic.

Teaching the rational object schema according to the method of stepwise formation of mental actions is systematic and leads to a more stable basis for performing quantitative comparisons between objects. The method of stepwise formation of mental actions has been applied successfully in various school subjects (reading, arithmetic) and in courses of training focusing on Piagetian concepts. Various experiments (see Kingma & Koops, 1988) have demonstrated that it is possible to use training to induce a rational object schema in small children, after which they were capable of performing various different Piagetian tasks.

Criteria for Evaluating the Success of Training

A survey of various training experiments shows that different evaluation standards are used to measure training effects (Kingma, 1981; Tomic, Kingma, & TenVergert, 1993; Tomic, 1995a; Tomic, 1995b; Tomic, & Klauer, 1996). One of the most important standards was devised by Brainerd (1975a, 1975b), who describes the success of training in terms of <u>near-near</u> transfer, <u>near-far</u> transfer and <u>far-far</u> transfer. In the first instance, the posttest contains the same problems that the subjects have been trained in. The point is to study whether the children trained in these tasks score better on the posttest than the control group children, who receive no training. In the case of near-far transfer, the posttest presents problems related to the children's training but which were not included in the training program. A training effect is said to have occurred when the trained children are able to solve the near-far transfer problems better than the untrained children. For example, they are better able to solve problems in conservation of weight, even though they were only trained in conservation of quantity. Far-far transfer, finally, also requires the children to have made progress in other types of tasks. For example, they might demonstrate a significant improvement in solving seriation problems even though they have only been trained in conservation problems.

We will continue this section with an observation related to Bruner's followers and their criteria for evaluating the success of training. Bruner, like Piaget, characteristically states that learning new principles should induce a change in representation. Bruner, however, does not work out how to use various tasks to measure whether training has in fact actually changed representation.

Many educational experiments employ Bruner's method for inducing a conflict between the forms of representation (appearance and reality). In most of these studies, researchers have not included a check to determine whether representation has been influenced by learning. According to them, the child's ability to find successful solutions to the tasks in which it has been trained is often decisive in determining whether training has been successful (see Kingma, 1981).

Bruner's ideas concerning the positive influence that education has on cognitive development appeals to a great many teachers. While it is true that Bruner's didactic instructions have been adopted, the issue of actual teaching success, i.e. a change in representation, is never raised. Because researchers who used Bruner's ideas as a basis for designing training experiments did not investigate whether training induced a change in the childrens' representation, we will proceed the description of evaluation criteria by focussing only on the Genevan school and the action psychology approach.

<u>Piaget's Criteria for Evaluating the Success of Training</u>

In both the design they use for training experiments and in the way they evaluate the effect of training, Piaget and his followers deviate from the methodology used by other educational researchers. According to Piaget and others, training methodology must resemble spontaneous cognitive development (Sinclair, 1973; Inhelder, Sinclair and Bovet, 1974). For this reason, the construction principle constitutes the core element of their training programs.

During training a child is offered various objects to manipulate. If the child has solved a problem, the experimenter questions him about his solution. It is important that the child not be told whether he has given the correct answer. The main idea behind this method is that self-discovery based on action represents the most suitable approach to teaching children cognitive skills. Direct guidance is not appropriate in teaching, because it will not induce an integrated change in the child's cognitive structure. A change in representation is linked to action and it is precisely guided teaching that will hinder the child's self-guided activity.

The nature of the initial condition, or rather the actual cognitive level of the child, will also determine to what extent training will be successful. Children can only benefit from training if they already possess some notion of the skill they are to be taught (Piaget, 1964a, 1964b; Inhelder et al., 1974). An important feature of Piaget's training design is that the training condition consists of two different groups. The children in the first group have already developed a certain amount of skill in the concept they are to be taught (for instance partial seriators, partial conservers). The children in the second group have no skill whatsoever in this concept (nonseriators, nonconservers). The classification is accomplished by means of a pretest, administered before the children begin their training. The pretest always consists of the same problems used in the training program itself (see Kingma, 1981).

During training, the experimenter attempts to match the actual cognitive level of the child. Depending on how the question-and-answer session proceeds, the child will be given a particular problem. The experimenter observes the way the child approaches the problem and the strategy he uses in attempting to solve it. Afterwards the child is asked why he chose that particular strategy, and whether he can think of other ways to reach a solution. Based on observations of the solution strategy and the child's arguments, the experimenter selects a new task for the child. As this description demonstrates, Piaget's training procedures are not standardized. During training the children do not all receive the same experimental treatment. Usually training takes place in two to three sessions lasting fifteen to twenty minutes each.

After training the children are administered a posttest consisting of a number of problems. For a training effect to reflect a change in the child's cognitive structure, it must meet the following Piagetian standard, consisting of three criteria: First, the training or learning effect should be evaluated from the perspective of spontaneous cognitive development. The crucial question is whether training has brought about a change in the entire cognitive structure. Second, skills should have been transferred to concept areas in which the child has not been trained. Third, the training effect should be durable.

The first criterion implies that the child's cognitive level must be determined before and after training. With respect to the level after training, the researcher must establish that cognitive functioning has undergone a definite change compared to the initial level. The object is to determine whether the learning experience has resulted in a more complex structure.

The second criterion is an operationalization of the first: the translation of the theoretical concept of change into measurable terms. Transfer means the application of newly acquired knowledge and skills in different situations. To measure the range of the transfer, the posttest includes problems related not only to the specific area in which the child was trained, but also to other conceptual fields. For example, if training involved conservation of number, then the posttest would include not only conservation of number problems but also conservation of quantity (Inhelder et al., 1974). However, even if a child can solve both types of conservation problems correctly (that is, in addition to finding the right answer the child also offers the right arguments for his solution), we still cannot conclude that training has given rise to a more complex cognitive structure. To determine whether this is so, the posttest must also set several tasks examining whether the change in the cognitive structure is such that we can detect an improvement in representation. For example, after undergoing training, a child is given a number of sticks. The experimenter tells the child to arrange the sticks from shortest to longest, thus constructing a little staircase (a series). Before the child performs the seriation, he is asked to draw a picture of the resulting arrangement of sticks on a piece of paper. To do this drawing, the child must be able to anticipate the result of the seriation. If the child draws the series of sticks correctly, arranged according to increasing or decreasing length, then it may be concluded that the learning experience did indeed lead to the development of a more complex cognitive structure. At times Piaget employed other problems, for example asking the child to insert a number of sticks in an existing series. The researcher can deduce indirectly whether the change in cognitive structure is such that representation has improved (see Kingma & Koops, 1988).

Determining a change in the cognitive structure is a necessary, but inadequate, criterion for determining whether training has been successful. The change observed must also meet the third criterion: it must be durable. In the Geneva training studies the long-term effectiveness of training is established by means of a second posttest administered a few weeks after the first one.

The results of Piaget's training experiments show that children who already possessed partial knowledge of a concept prior to training benefitted from a training program for the most part. Skills were transferred to various concept areas, representation improved greatly, and the learning effect or change appeared to be long-term in the cognitive structure. Children who had not demonstrated the slightest familiarity with the concept in which they would be trained (nonconservers, nonseriators) gained little or nothing from training. Most of the children showed no progress whatsoever. A few children at most reached the level of partial knowledge, that is to say that they did not show any progress in representation and did not make use of operational methods in seeking solutions. The children who had gained "partial knowledge" were also very likely to drop back a level on the posttest after a few weeks' time (see Inhelder et al., 1974).

Piaget believed that the results achieved in his training studies supported his theory concerning the relationship between development and learning. A child can only master the information he obtains through socioeducational transmission if he understands this information. The child must possess the skill to assimilate the information in his own cognitive structure. Clearly, the child must possess at least partial knowledge in order to assimilate the information. According to Piaget, then, education should not anticipate the actual cognitive level of the child, but rather keep pace with it. The issue is whether the child is ready to learn. This issue of "readiness to learn" generated a great deal of discussion in the early 1960s. Scores of researchers rebelled against Piaget's rather pessimistic views on the ability of education to influence cognitive development. What they often neglected to bear in mind was Piaget's belief that education has little or no chance of succeeding if the child does not understand the information.

The sharp rise in the number of training experiments in which children were taught Piagetian concepts (conservation, classification, seriation) culminated in a gigantic database concerning training effects. Upon closer inspection, however, it appears that the majority of researchers employed criteria, "evaluation standards", other than Piaget's to determine the success of training. This does not put them in a position to reject his views on the relationship between development and learning. In most of these experiments, the researchers neglected to investigate whether training affected the child's representation and whether the learning effect was long-term (Kingma, 1981).

Criteria for Evaluating the Success of Training According to the Action Psychology Approach

The standard used by Gal'perin to determine the success of a course of training is highly similar to the requirements set by Piaget for successful training. Broadly speaking, Gal'perin's requirements (Obuchova, 1966) consist of the following elements:

a. instruction must induce a transferable structure of action;

b. the effect of training must be durable.

To determine whether training has resulted in a transferable action structure, children are given a wide range of tasks to perform after being trained. As described earlier, the tasks may be described in terms of near-near transfer tasks, near-far transfer tasks and far-far transfer tasks (Brainerd, 1975, 1976).

The three types of tasks give an impression of the range of transfer studied by Gal'perin's followers. These researchers do not use the term transfer, however; rather, they talk of research into the functioning of the learning outcome, indicating by this that in the case of a positive training effect, the action structure (meaning the representation) has changed. Such a change can be deduced from the children's performances on the three types of transfer problems described previously. A significant similarity to Piaget's standard with respect to the success of training is, therefore, the wide range of tasks set for the children on the posttest.

The second requirement, that the effect of training should be durable, also resembles Piaget's standard. Closer analysis reveals that Gal'perin's standard for evaluating the success of training is in fact much stricter than Piaget's criterion (Kingma, 1981). It is precisely the child's ability to meet these strict criteria that makes it possible to decide that an action has been internalized and that symbolic representation has therefore advanced to a higher level.

Concluding Remarks and a Look Ahead

The development of representation is the main theme of three "classic" and influential theories on learning new concepts.

Opinions differ widely as to the relationship between cognitive structure and cognitive function. For Piaget, structure must change before a change in representation is noticeable. Education must keep pace with the actual cognitive level of a child, so that the child can understand (assimilate) the information. It is the conflict between the appearance of an object and what it actually is that in fact induces a change in the structure. The child's intrinsic activity and motivation together form the dynamic motor of the process that will lead to the resolution of such a conflict. The best approach to learning is the method of self-discovery, in which the teacher remains in the background, offers suitable material at the appropriate time, and continuously asks questions that will encourage the child to justify his solutions. The teacher does not provide any feedback whatsoever.

Piaget is rather skeptical about the possibility of influencing cognitive development through training. Only children who already possess partial knowledge of the concept in which they are to be trained can benefit from training. The success of a training program can be deduced from the results and the way in which children solve a wide range of tasks on the posttest (near-near, near-far, far-far transfer problems). In addition, the results must also be durable. Only then is it correct to assume that the child's representation has changed.

Bruner's theory concerning the development of representation emphasizes function: the various forms of representation. The conflict between different modes of representation gives rise to further development. This conflict can be guided by an adult (guided discovery). Bruner, like Piaget, considers self-discovery the best way to learn. At first children will often need to be encouraged to learn something new under the guidance of an adult, but later they will go on to explore the subject independently (from extrinsic to intrinsic motivation). In contrast to Piaget, Bruner believes that education should anticipate the actual level of the child. New, interesting subjects are the vehicle for motivating children. The function of learning is to advance representation to a higher symbolic level.

These theoretical ideas reflect the Zeitgeist of the sixties and seventies, when many American researchers demonstrated a great deal of optimism about the possibility of influencing cognitive development through short-term training. Although we are overstating the case somewhat, we could say that what the American neo-Piagetians intended was to use training experiments to reduce "development" to what it actually "should" be in behaviorist terms: the result of overt learning processes. The relevant research was and is characterized by a certain sterility: research took the form of simple training experiments conducted in specific laboratory settings and producing small-scale significant but nevertheless weak effects (Kingma, 1981; Kingma & Koops, 1988). If the results of these American studies are analyzed by applying Piaget's standard for measuring the effect of training, as well as his criteria, then they appear to have produced rather specific, short-term training effects with only a small degree of transfer (usually near-near; sometimes near-far). What stands out is that many of these studies do not even bother to investigate how long the effect lasts.

"We may correctly conclude that the unrestricted optimism concerning the degree to which development might be influenced - the origin of which can be traced to the behavioristic past of the researchers concerned - apparently led them to be satisfied with very weak empirical evidence" (Kingma & Koops, 1988, p. 215).

Despite the large number of researchers who took Bruner's ideas concerning the development of representation as the starting point in designing their training studies, more than 97 per cent of these studies did not investigate whether training did in fact bring about a change in the students' representation (see Kingma, 1981).

In addition, these training studies often used different criteria to assess the transfer problems. For example, in a conservation problem a child would only be asked to assess whether a particular aspect had remained constant after a change in shape had taken place. This measuring procedure is more likely to produce positive results than if the child were asked to offer correct and logical arguments for its evaluation, as required by Piaget. Piaget and the American researchers differ on the issue of criteria in two distinct areas, namely: (a) in the area of transfer problems, and (b) in the area of standards applied to evaluate the effect of training.

The criteria applied by American researchers to evaluate the effect of training are less strict than Piaget's and Gal'perin's. Seen in this light, it is no surprise that they are more likely to obtain a positive result. If researchers fail to establish clear-cut criteria for evaluating training results beforehand, then we do not know where we stand. Judged by Piaget's standard, most of the American training studies fall by the wayside. At most, they can only be interpreted as successful in the sense that training gave rise to isolated schemata. Representation remained unchanged by this. The isolated nature of the newly acquired knowledge means that it will quickly be forgotten (Piaget, 1964a, 1964b). This consideration seems to support Piaget's pessimistic view on influencing cognitive development through education. This view is negotiable, nonetheless, because Gal'perin's method of stepwise formation appears to accelerate cognitive development successfully, both in Piagetian concepts - conservation (Obuchova, 1966), anticipation of seriation (Burmenskaja, 1976) and class inclusion (Lider, 1978)- as in various school subjects - arithmetic (Gal'perin and Georgiev, 1960), geometry (Gal'perin & Talyzina, 1957), spelling (Ajdarova, 1964; Ajdarova, Gorskaja & Cukerman, 1976) and reading (El'konin, 1963).

The conservation training method developed by Obuchova (1966) is exemplary for designing a methodology for the stepwise formation of mental actions. Nonconservers learned to deal with units of measurement (Tomic, Kingma, & TenVergert, 1993). The results were favorable: after being trained, the children were able to perform all conservation tasks correctly - without taking measurements (Van Parreren, 1979). The posttest revealed that the training effect had lasted as long as one month after training. Burmenskaja replicated Obuchova's training experiment and confirmed the previous results. Moreover, training appeared to have produced far-far transfer effects. On the posttest the children were able to solve problems in concept areas in which they had not been trained (seriation and class inclusion).

These major and durable effects were also observed by Lider (1978) and Tomic et al. (1993) in the application of Obuchova's training methodology. A broad, solid transfer effect such as this is quite rare in training research. The wide range of posttest tasks (near-near, near-far and far-far transfer tasks) is necessary to determine how the learning outcome functions. This method of determining the effect of training is highly similar to the standard used by Piaget. The results of training studies in which Obuchova's methodology is applied satisfy Piaget's stringent requirements in this respect.

The pedagogical optimism based on these and other successful applications of Gal'perin's method of the formation of mental actions caused many teachers to view Russian psychology as a blueprint for designing various teaching methods. The two basic characteristics of Russian psychological research - on the one hand research embedded in the regular classroom learning process, on the other research focused on transferability, the range of transfer, and on the duration of educational interventions in the thought processes of children - have a great deal of authority with educational psychologists. The dangers of this practical orientation are twofold.

> "... But once Soviet research moves out of the laboratory, the control group disappears, systematic data yield place to anecdotal accounts, and the 'transforming experiment' degenerates into a dutiful demonstration of ideologically

prescribed processes and outcomes" (Bronfenbrenner, 1976, p. 198).

Second, Russian psychology has often been viewed as an alternative to Piaget's approach to the relationship between development and learning, even though it is largely a variant of Piaget (Koops, 1983).

This criticism made it necessary to replicate earlier "successful" experiments using a correct form of data analysis, adequate controls and appropriate adherence to Piagetian training criteria. Kingma and Loth (1984) applied the training methodology devised by Obuchova in an experiment involving preschoolers and which met stringent methodological requirements. They confirmed both Obuchova's (1966) and Burmenskaja's (1976) previous results. Children participating in their training program demonstrated convincing progress in performing conservation and seriation tasks on the posttest, although they had been unable to perform the same two types of tasks on the pretest (nonconservers, nonseriators). The improvement lasted up to four months after training on the third posttest. The training group consistently achieved better results for both types of tasks on the posttests than the children in the control group. On the final posttest, two years after training, the control group had caught up to the training group. The results of this training study were compared to results achieved in previous research, both longitudinal and cross-sectional.

The comparison revealed that both nonconservers and nonseriators could advance to a level that children left to develop "spontaneously" would only reach two to three years later than those who had undergone training. The training study conducted by Kingma and Loth (1984) shows that by using Gal'perin's basic premise, we can influence cognitive development in an effective manner. We may conclude that if we apply stringent Piagetian training criteria (range of transfer and durability) and use an adequate control group, a similar type of training program will stimulate cognitive development, and therefore a change in representation, in children who prior to training had no notion whatsoever of the concepts in which they were to be trained. Similar findings were observed in seriation training (Kingma & Koops, 1984d) based on a method devised by Levinova (1977) and in seriation training (Kingma & Loth, 1983) based on the American method devised by Hooper (1973).

The question remains whether Piaget's view concerning the relationship between development and learning has been undermined entirely. Piaget's position in this connection (1964a, 1964b) was supported by the results of short-term training experiments conducted by American researchers. Inhelder et al. (1974) describe in their Geneva studies that children who had partial knowledge of the concept in which they were to be trained benefitted from two to three training sessions lasting ten to twenty minutes each. In terms of duration, these Piagetian training studies resemble the majority of American investigations. Applying the stringent standard maintained by Piaget to the results of these short-term training programs reveals that training has no dramatic impact on the representation of children who had no prior notion of the concepts in which they were to be trained. We can nuance Piaget's position in so far as it relates to short-term training. If the sessions are extended over several weeks or months, as is customary in Russian psychological studies, then training does appear to stimulate cognitive development. In the training study conducted by Kingma and Loth (1984), for example, children were trained twice every school day for four weeks, each session lasting between 20 and 25 minutes. In other words, the amount of training is considerably larger in Russian research than it is in American research. Stimulating development and in turn stimulating changes in representation is a difficult and time-consuming process. This is the essence of what Piaget was driving at: short-term training is not the appropriate means to induce long-term developmental effects. Piaget, Gal'perin and Bruner all agree on this point.

The results achieved by the different theoretical schools teach us that, if education is intended to influence cognitive development, then investigations are required into whether and to what extent it changes representation. "Monkey see, monkey do" - imitation - is easy to learn. To bring about a conceptual change remains a difficult and time-consuming affair in the classroom learning process, particularly when the issue involves a change in representation.

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