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JEAN PIAGET AND THE WORLD OF THE CHILD¹

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WE have gathered today to honor the University of Geneva on its four hundredth anniversary. As a citizen of a nation not yet 200 years old—and as a member of a University which has not quite rounded out its first century of service, I feel considerable awe at a city state which measures its age in millenia, and at a University which has endured 4 centuries—a University so venerable that in comparison our oldest American university is young. I am sure I speak not only for myself, but for generations of foreign students at Geneva, in expressing gratitude for the intellectual stimulation and opportunity for growth which Geneva has for so long offered to so many.

For many visitors, the central symbol of Geneva is the Palais des Nations—home of the League and now of the United Nations, impressive both as a building and as the objectification of an ideal. But when we think of Geneva's international importance, we sometimes forget that its selection by world organizations—the UN, the Red Cross, and the rest—was not the cause, but the consequence of Geneva's identification with peace, with the rule of law, and with the hope of international friendship.

A better symbol is the University, which stands in the Rue de Candolle, serene and dignified despite bursting throngs of students and the encroaching noise and traffic of the modern city; for the University best exemplifies the spirit of Geneva—a spirit of independence forged by the stubborn Calvinists of the Reformation, when Geneva was a beleaguered island of dissent fighting for survival against a surrounding sea of orthodoxy. That spirit, strengthened and liberalized by philosophers as diverse as Rousseau and Voltaire who both

found refuge there in later ages, evolved ultimately into a spirit of freedom, and of hospitality to new ideas. It is this spirit we salute, in honoring the University of Geneva.

This spirit, nurtured through 400 years, has fostered the assemblage at Geneva of a university faculty which though not large, is not easily matched in distinction. Among the most renowned is Jean Piaget, who has been for more than 40 years engaged with his associates in a prodigious program of research and theory building which will have, I am sure, a lasting influence upon American psychology.

It is difficult to characterize Piaget's work, for it is both deep and broad in scope. He has been in turn a biologist, psychologist, philosopher, and logician, and in all four fields he has made major contributions. He is currently Professor of Psychology at the University of Geneva and at the Sorbonne. He is coeditor of the *Archives de Psychologie* and of the *Revue Suisse de Psychologie*. He is Director of the Institut des Sciences de l'Éducation (successor to the Institut Jean Jacques Rousseau), founder of the Centre d'Épistemologie Génétique, and Director of the Bureau International de l'Éducation, an affiliate of the United Nations Educational, Scientific, and Cultural Organization, which entitles him to the black passport of diplomatic status. Widely traveled, he has been honored by many foreign universities and governments. He is a member of the French Légion d'Honneur and holds honorary doctorates from the Sorbonne, from Brussels, Brandeis, Harvard, and other universities.

Since his book, *the Language and Thought of the Child*, appeared in 1923, Piaget and his collaborators have published more than 20 full-length books and largely filled 30 bulky annual volumes of the *Archives de Psychologie*; in all, over 180 major studies covering thousands of pages, of which the barest fraction has been translated into English. I am acquainted with only a small part of this fantastic productivity, and considering the brief time

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² The author wishes to acknowledge his indebtedness to earlier writers on Piaget, not all of whom could be mentioned in the lecture. However, special acknowledgment is owing to Flavell (1962) in connection with the biographical account, and to Wolff (1960) for portions of the summary of theory.

at my disposal, it may be just as well that my knowledge of it is not encyclopedic. In any case you will understand why this morning's talk is scarcely a preface to an introduction to Piaget.

Now in spite of his stature in the field, there is nothing remotely pretentious about Piaget. As many of you know, he paid a brief visit to Berkeley in March (1964). If you were fortunate enough to attend his evening lecture, I need not tell you of his personal charm and wit which withstood the rigors of translation from one language to another. For those who did not attend, a word of description may not be amiss.

Imagine a man approaching 70, a man of average build, of clear and ruddy complexion, and with snow-white hair worn long over his collar. He moves deliberately, but his blue eyes sparkle with youth, good humor, and zest. Benevolent enough, but not heavy enough, to look like Santa Claus, he reminds one faintly of the pictures of Franz Liszt that have come down to us. A man of great vigor, he still bicycles the several miles from his home to his office in the Palais Wilson and back again each day: and despite a man-killing schedule of conferences and meetings here in Berkeley, he wore out relays of us who tried to entertain him, and had energy left to spare for private hikes in Strawberry Canyon.

It was my privilege to introduce him to San Francisco on a Sunday of perfect temperature and brilliant sunshine. He found San Francisco "formidable," but astonished me by saying that what he particularly wanted to do, was drive the Lombard Street hill, "the one that curves back and forth like a snake." I had never driven it and did not much want to, so I took him up to Coit Tower in the hope he would settle for seeing the street in the distance. He enjoyed the view from Telegraph Hill and appreciated not only the tower itself but also its name. (Parenthetically, there has been some question about the influence of Freud upon Piaget. There is not much evidence of influence, but I assure anyone who doubts it, that he is familiar with psychoanalytic symbolism and loves a pun.)—But then he said, "Now let's go drive down the twisting street."—So there was no help for it. We went, and a child on a roller coaster could not have enjoyed the steep climb and abrupt descent any more than he did.

Later he admired Sausalito and Muir Woods, but although a passionate botanist by avocation, his

real affection is reserved not for redwoods, but for succulents—especially sedums. If there are present today any residents of Mill Valley, you may have seen us stopping before several gardens containing sedums, while Piaget got out and took a promising cutting to carry back to Geneva. If a policeman had stopped us, I would probably have just kept still and left it to Piaget's warm smile and eloquent French to keep us out of jail.

Now Piaget's botanical interests represent, to a degree, a change from his earliest interest, which was in zoology. Born in Neuchâtel in 1896, he published his first paper when he was 10 years old on an albino sparrow he found hopping in the public garden. His interest soon turned to molluscs. Before he was 21, he had published 20 papers on molluscs and related topics, and had been offered sight unseen the curatorship of molluscs at Geneva while still in secondary school. He took his baccalaureate at Neuchâtel in 1915 followed by his doctorate in 1918.

Throughout these early years he read widely in other fields—religion, philosophy, and psychology. He came thus to the view that biology should contribute to the solution of classical problems in epistemology, but realized that something was needed to bridge the two. In later years, his developmental psychology came to provide the link, culminating in his three-volume work of 1950 on genetic epistemology, unfortunately still untranslated.

After receiving his doctorate, his interests shifted more explicitly to psychology, and he left Neuchâtel to visit and study at various other centers, including Bleuler's psychiatric clinic and the Sorbonne. Binet had died in 1911, but in Paris, Piaget was given the opportunity by Simon, Binet's collaborator in the Simon-Binet tests, to work in Binet's old laboratory at a Paris grade school. The problem suggested was a standardization of Burt's reasoning tests on Paris school children. Although Piaget was not much interested in the psychometric aspects of the problem, he found himself fascinated by the processes whereby the child achieved his answers—and wrong answers were often more enlightening than right ones.

The psychiatric examining procedures learned at Bleuler's clinic were pressed into service to elucidate the child's reasoning, and came ultimately to constitute the *méthode clinique* by which much of Piaget's data have been collected. This method of

intensive interrogation is common enough among psychiatrists, but it is likely to scandalize the American psychologist trained in the canons of objectivity and standardization of procedure, because it risks leading the child and putting words in his mouth. Yet in skillful hands, it yields subtle insights which our "measurement" approach precludes.

In view of his work in Binet's laboratory, it is interesting to trace Piaget's relation to the great French psychologist who had died when Piaget was in adolescence. Certainly Piaget has relatively little in common with the Binet of the famous intelligence tests, because Piaget has never been much interested in mental testing or in individual differences. But he has much in common with the Binet of earlier years, whose interests, like Piaget's, ranged over much of science. More specifically, he seems the direct heir of the Binet who wrote the famous volume, *The Psychology of Reasoning*, a book which anticipates Piaget in its concern with the subtle qualitative aspects of thought, and further anticipates him in the employment of the psychologist's own children as experimental subjects—a procedure which might be impractical in this country where statistically adequate samples of 40 or 50 are a desideratum for the simplest investigation!

In 1921 Piaget published four papers describing the results of his work with Burt's tests and other such problems. On the strength of them, Claparède, who was then the Professor of Psychology at Geneva, invited Piaget to the post of Director of Studies at the Institut Jean Jacques Rousseau, and Piaget accepted. Although at first he divided his time between Geneva and Neuchâtel, and until fairly recently spent part of each week at the Sorbonne, his work for the last 40 years has been largely identified with the University of Geneva.

In all the vast corpus of Piaget's work are there unifying trends or concerns which can serve to orient us in this brief survey? Apart from his zoological studies and a few mathematical papers on logic as such, the central preoccupation has been with epistemology—the fundamental problem of how we come to know our world. But this problem is approached, not via traditional philosophical speculation, but rather via scientific observation and experimentation, although sometimes of an unconventional kind. The subjects are

infants, children, and adolescents, and the emphasis is always developmental.

Some of this work is on perception, and is concerned with discovering the laws of perceptual development and the differences between perceptual and cognitive functions. To this end, the Geneva workers have shown a persistent interest in optical illusions. For example, they have systematically altered various aspects of the stimulus configuration and measured the magnitude and direction of the observer's errors as a function of his age. These perception studies, over 40 in number, are more rigorous and quantitative than the studies on cognitive development, and substitute for the *méthode clinique* the traditional experimental approach.

In summary, Piaget finds a general tendency, though by no means a linear one, nor one found in all instances, whereby perceptual judgments grow more accurate with age. However, he regards perceptual development as essentially continuous, and he does not consider that the developmental stages, which are so important in his cognitive theory, exist in the perceptual domain. Indeed, he has repeatedly contrasted the perceptual versus the conceptual or inferential process even in the young child, and emphasized that the two functions follow very different paths in development. Wohlwill (1962) has suggested that Piaget's denial of stages in perception while affirming them for cognition stems not from the finding that ontogenetic change in perception is necessarily more gradual, but rather because the differences between successive perceptual achievements are only quantitative, whereas one can find structural criteria—that is to say the presence or absence of particular logical operations—to differentiate the stages of conceptual development.

Time precludes further discussion of the Geneva work on perception, though it constitutes a large and important body of data and interpretation for the perception psychologist. Let us turn instead to the more familiar studies concerned with reasoning and inference.

To throw Piaget's contributions into sharper focus, let us digress briefly to consider the epistemological problem, one of the great imponderables which have engaged men's attention at least since the golden age of Greek philosophy. Now philosophers often ask questions in ways which admit

of no final answer. They thus get a great deal of mileage out of them, and the same controversies keep recurring, century after century. For our purpose we need go no further back than the views of the British associationists of the seventeenth and eighteenth centuries.

The epistemological problem has to do with the nature of reality and of our knowledge of it. It probably never occurs to the naive man in the street to question the objective reality and existence of the things of the physical world—tables, chairs, people, books, etc.—which we see all about us. So uncritical an attitude does not characterize philosophers, though different ones have taken opposite sides of the question, sides to which we give the general labels “empiricism” and “idealism.”

John Locke (1947) was an empiricist. Writing near the end of the seventeenth century, he rejected the idealist doctrine offered by Descartes and tracing back through the scholastics to Plato, that the mind comes furnished a priori, with a considerable array of innate ideas. Instead he sponsored the view, then much less familiar than it is now, that *all* knowledge is derived from experience. In Book II of his great *Essay Concerning Human Understanding*, he writes,

Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas; how comes it to be furnished? Whence comes it by that vast store, which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer one word, from experience: in that all our knowledge is founded, and from that ultimately derives itself [p. 26].

And again in Book IV,

Since the mind in all its thoughts and reasonings hath no other immediate object but its own ideas, which it alone does or can contemplate, it is evident that our knowledge is only conversant about them [p. 252].

From this it would seem to follow that we cannot know of the existence of other people, or of the physical world; for these, if they exist, are not merely ideas. Each one of us, so far as knowledge is concerned, is shut up in himself and cut off from contact with the world.

Now Locke usually shrank back from drawing the implications of his theories when they seemed to run counter to his own common sense. George Berkeley, Bishop of Cloyne, is best known in

California for our city of Berkeley which was named for him, although he might not recognize his own name as we pronounce it. In philosophy, he was an immediate successor of Locke and set out to resolve Locke's inconsistencies. Boldly pushing Locke's views to their logical consequence, he found himself in the position of denying the very existence of matter, i.e., the external world, and affirming that only the mind is ultimately real. He asserted that material objects exist only through being perceived. Bertrand Russell (1945) puts the matter very clearly.

To the objection that, for example, a tree would cease to exist if no one was looking at it, he replied that God always perceives everything; if there were no God, what we take to be material objects would have a jerky life, suddenly leaping into being when we look at them; but as it is, owing to God's perceptions, trees, rocks, and stones have an existence as continuous as common sense supposes. This, in Berkeley's opinion, is a weighty argument for the existence of God [p. 647].

Berkeley's idealist view seems intuitively false to at least some philosophers, and to most people who are not philosophers, but it is hard to refute. Berkeley's finding himself in the idealist camp by merely seeking to embrace the implications of the empiricist position shows how slippery some of the central questions of philosophy can become when phrased in traditional forms. Obviously such questions as, “Is there an external reality?” or even merely, “What is knowledge?” can lead only to speculative controversy. If the epistemological problem is formulated in more restricted terms of *how* is knowledge acquired, rather than *what* is knowledge, it may become susceptible of scientific experimental attack.

Returning to Piaget, it is clear that his genius has lain in his resourcefulness in investigating the more manageable question, “How does knowledge develop and change?” As you can see, Piaget's epistemology is at once empirical—even experimental—and developmental in orientation. Leaving aside the question of whether the world is real, he has observed and recorded the activities of the child from earliest infancy to adolescence in acquiring the strategies for coping with it.

On the traditional epistemological issue, Piaget is hard to classify. Some have considered him an idealist, some an empiricist, and both sides can marshal quotations in support. Bärbel Inhelder (1962, p. 20) writes amusingly about this. It seems that after considerable contact in a seminar,

Konrad Lorenz remarked, "All along I have thought that Piaget was one of those tiresome empiricists, and only now after studying his work on the genesis of the categories of thought, have I come to realize that he is not so far removed from Kant." On the other hand, some Russian colleagues who believed Piaget to be an idealist because he did not admit that knowledge of the external world is simply a reflection of the objects in it, posed to him the following leading question: "Do you think an object exists prior to any knowledge of it?" Piaget replied, "As a psychologist, I have no idea; I only know an object to the extent that I act upon it; I can affirm nothing about it prior to such an action." Then one of the Russians said, "For us an object is part of the world. Can the external world exist independently of and prior to our knowledge of it?" To this, Piaget replied, "The instruments of our knowledge form part of our organism, which in turn forms part of the external world." Later, Piaget overheard them talking and agreeing, "Piaget is not an idealist."

Perhaps the difficulty of locating Piaget unequivocally on the empiricist-idealist continuum illustrates a central problem for the student of his work. His ideas are highly original. The terms he has coined for his central theoretical constructs are not merely unfamiliar. They seem vigorously to resist translation into other people's conceptual categories. There is no help for it, if one would understand his theories, but to try to assimilate Piaget in his own terms.

I shall try in the next few minutes to communicate a little of his theory of cognitive development which you may or may not choose to accept. In either case, his empirical findings are an enormously important body of data for students of very different theoretical positions.

Let us turn first to Piaget's theory of cognitive development. Here a confusing situation arises for the English-speaking student. Piaget's five important books of the early 1920s were translated fairly promptly into English in the first flurry of interest in his work. These volumes—*Language and Thought of the Child*, *Judgment and Reasoning in the Child*, *The Child's Conception of Physical Causality*, and *The Moral Judgment of the Child*—are widely available. It is their contents—the famous inquiries about what makes clouds move, the origins of dreams, the basis of rules for games,

and a host of other such topics—which come to mind for many people when Piaget is mentioned.

Now these works were gradually superseded in Piaget's theoretical formulations, but the point has not been sufficiently appreciated. In this country, there was a decline of interest in Piaget during what Koch (1959) has called the "Age of Theory" in American psychology—roughly from the early '30s to the end of the war—a tough-minded period dominated by the rules of "hypothetico-deduction" and "operational definition" and animated by belief in the imminence of a precisely quantitative behavior theory. Piaget's work was not easily reconciled with the fashions of the period, and little was translated. Now the tide has turned, and at least a portion of Piaget's recent work is available in English, not to mention several excellent "explanations" of him by Wolff (1960), Wohlwill (1960), Hunt (1961), and especially Flavell's comprehensive volume of 1963. However, the essential continuity of development of Piaget's ideas is obscured by the discontinuity of translation. So different are the recent works from the old ones, that to read them one must master a new vocabulary and a new theoretical formulation, and this time the task is made more difficult by the heavy emphasis upon propositions of symbolic logic to explicate the developmental stages of reasoning.

To the early Piaget belonged the painstaking compilation of the forms of verbal expression according to age level from 3 years to 10 years: the demonstration that children's "explanations" of phenomena pass through *stages*, from early animistic, through magical and artificialist forms, to rational thought, and that at each level, the child constructs a systematic "cosmology" according to the modes of reasoning available to him at that stage. The empirical bases for these findings were the children's verbalizations as elicited by the *méthode clinique*, with its inherent risks of misinterpretation of what the child is trying to express. Piaget was severely and perhaps unjustly criticized on this account, for he was sharply aware of the problem. As he put it (1929),

It is so hard not to talk too much when questioning a child, especially for a pedagogue! It is so hard not to suggest! And above all, it is so hard to find the middle course between systematization due to preconceived ideas, and incoherence due to the absence of any directing hypothesis! . . . In short, it is no simple task, and the material it yields needs to be subjected to the strictest criticism [p. 8].

In retrospect, Piaget (1952a) recognizes that his method in those years was much too exclusively verbal.

I well knew that thought proceeds from action, but believed then that language directly reflects the act, and that to understand the logic of the child one has to look for it in the domain of verbal interactions. It was only by studying the patterns of intelligent behavior of *the first two years* that I learned that for a complete understanding of the genesis of intellectual operations, manipulation and experience with objects had first to be considered [p. 247].

As Piaget notes, the shift from reliance on verbalization to observation and experiment is most important for genetic epistemology because it permits one to study infants as well as the later stages of growth, and by more or less comparable methods.

The cognitive theory starts from the central postulate that motor action is the source from which mental operations emerge. The *action* of the organism is central to the acquisitions of the operations (i.e., ideas, or strategies), which we acquire for coping with the world. In the Hegelian dialectical form which his lectures often assume, Piaget contrasts his emphasis upon the active interplay of organism and environment, both with the environmentalist view in which experience or conditioning is impressed upon a passive organism, and with the nativist view that intellectual capabilities exist preformed and merely unfold in the course of development.

Motor action is *adaptive*, and so are the cognitive activities which more and more replace overt motor behavior. Piaget's biological orientation is seen in his assertion that intelligence is an adaptation, and only one aspect of biological adaptation. Intelligence is an organizing activity which extends the biological organization. With respect to intelligence, a subject to which Piaget has given much attention, it should be noted that his interest is in the typical, not in the range of variation. For him, the word "intelligence" lacks the mental-testing connotations with which it is usually invested in English, and corresponds rather to "intellect" or to intellectual activity or adaptation.

Life is a continuous creation of increasingly complex forms, and a progressive balancing of these forms with the environment [Piaget, 1952b, p. 3].

Intellectual adaptation is the progressive differentiation and integration of inborn reflex mechanisms under the impact of experience. The differentiation of inborn reflex structures and their functions give rise to the mental operations

by which man conceives of objects, space, time, and causality, and of the logical relationships which constitute the basis of scientific thought [Wolff, 1960, p. 9].

Another central postulate is that intellectual operations acquired by interaction between organism and environment are acquired in a *lawful sequence*. It should be emphasized again that Piaget's concern is with elucidating the sequence, *not* with establishing exact age norms for its stages. It should also be noted that Piaget has set out to write the ontogenetic history of cognition—*not* a complete account of personality development. What lies outside the cognitive domain is rigorously excluded.

The innate equipment consists of reflexes present at birth. A few reflexes, e.g., yawning or sneezing, are relatively fixed and unmodifiable by experience, though some, like the Babinski, change with maturation. The majority of reflexes, for example, grasping, *require* stimulation for their stabilization, are modified as a result of experience, and constitute the basic behavioral units from which more complex forms of behavior emerge. Most important, the feedback from the activation of a reflex alters all subsequent performance of that reflex. Thus, behavior is simultaneously determined by: first, the inborn structure; second, past activations, i.e., experience; and third, the particular present situation.

Now corresponding to each innate reflex there is assumed to exist in the mind a reflex *schema*, which will not become a stable structure unless repeatedly activated by external stimulation. The concept of schema is difficult. It is described as a flexible mental structure, the primary unit of mental organization. It is too invested with motor connotations to translate as "idea"; and being initially innate, it can hardly be a memory trace. Yet it covers both, and when fully developed bears some resemblance to Tolman's sign Gestalt.

When a reflex responds to a suitable external stimulus, the total sensory perception *and* motor activity are incorporated into the schema of that reflex, and change it; so that when the reflex is again stimulated, the schema has been modified. The stimulus is never again experienced in quite the same way, nor is the response quite the same. Thus the schema is invoked to account for the modification of response, *and* for the alteration of perception in the course of learning. In other words, the organism experiences and reacts to the

environment always in terms of an existing organization. All experiences of a particular kind are molded into the already present schema, and in turn alter it according to the reality conditions. Hence, experiences are not recorded as isolated stimulus-response connections, or engrams impressed on a passive brain field, but are integrated into a constantly changing structure.

For the dual aspects of learning, Piaget has used the terms *assimilation* and *accommodation*. He points out first that there exists a fundamental coordination or tuning of the organism to its environment. We have eyes and skin receptors preadapted for the photic and thermal radiation found on earth, ears for sensing rapid waves of pressure in earth's atmosphere, and so forth. There exists, moreover, a fundamental tendency of organisms to take in substances and stimulations for which there already exist the appropriate internal structures and organization. This taking in is called *assimilation*. At a biological level, it refers to the physical incorporation of suitable nutrients into organic structure. At a primitive psychological level, it refers to the incorporation of the sensory and motor components of a behavioral act into the reflex schema they have activated. At more complex levels, assimilation refers to the tendency of the mental apparatus to incorporate ideas into a complex system of thought schemata.

Parallel to assimilation is the function of *accommodation*, i.e., the process by which a schema changes so as to adapt better to the assimilated reality. At the biological level, accommodation refers to modification of the organism in response to stimulation, e.g., skin tanning in response to sunlight, or muscle growth in response to exercise. At the lowest psychological level, it refers to the gradual adaptation of the reflexes to new stimulus conditions—what others have called conditioning or stimulus generalization. At higher levels it refers to the coordination of thought patterns to one another and to external reality.

While assimilation and accommodation seem not too far from conventional learning theory, the concept of *aliment* is more unfamiliar. Whatever can be assimilated to a schema is aliment for that schema. Now the aliment is not the *object* which seems from the point of view of the observer to activate behavior, but rather those properties of the object which are assimilated and accommodated to. For example, a nursing bottle filled

with milk may be organic aliment for the metabolism, sucking aliment for the reflex sucking schema, and visual aliment for the visual schema. And if the idea strikes you as bizarre that a reflex requires to be fed, as it were, by appropriate stimulation, consider Riesen's (1947) report on the degeneration of the visual apparatus in chimpanzees reared in the dark—or the more familiar degeneration of unstimulated muscles when polio destroys the motor pathways.

Why the careful distinction between an object and its properties? Because for the infant the object does not exist! The idea of an object grows gradually out of the coordination of several schemata—that which is perceived by several sensorial avenues *becomes* the object. At first, the infant has not even awareness of the boundaries of his own body. Objects in the perceptual field—including his own hands and feet—are responded to according to the infant's limited reflexive repertoire. He sucks in response to oral stimulation, grasps in response to palmar stimulation, but makes no attempt to grasp the nursing bottle which he competently sucks, or to follow visually the bottle he can clutch if placed in his hand. Only gradually, by a process called generalizing assimilation, do stimuli which were initially specific aliment for one schema become aliment for other schemata. In parallel accommodation, a schema becomes attuned to more complex inputs, and tends to become coordinated with other schemata which are simultaneously activated. When this happens, things previously known tactilely by being grasped can be recognized by sight alone. Similarly, grasping attempts of increasing accuracy can be directed toward sources of visual stimulation. In such a fashion does the baby come to populate the world with objects, one of which is his own body, which supplies him at once with visual, tactile and kinesthetic stimuli—and when he cries, with auditory ones.

However, the infant still does not attach the concept of permanence to objects. "Out of sight" is quite literally "out of mind." One of Piaget's most interesting experiments—and one which can be repeated by any parent of an infant—concerns the growth of the idea of permanent objects. If you catch a young baby's attention with a small toy, and then hide it, he will make little response. When somewhat older, he will show diffuse motor behavior. If now he once happens to touch it,

he will gradually learn to search more efficiently where the object is hidden. However, if the object is hidden in a different place, in full sight of the baby, he will search not where he saw it hidden, but where previously he had touched it. It is an intellectual achievement of some magnitude when the very young child learns to coordinate the space of things seen with the space of things touched, and seeks to touch an object where hitherto he has only seen it.

We can conclude our rapid survey of Piaget's basic concepts with a brief reference to *equilibrium*. Bruner (1959), otherwise most sympathetic, regards the notion of equilibrium as excess baggage, contributing to Piaget a comforting sense of continuity with biology, but offering little else. Perhaps the idea of disequilibrium is more easily described. A schema is in disequilibrium if adaptation (i.e., assimilation and accommodation) to the stimulus is incomplete.

It seems to me that the ideas of equilibrium and disequilibrium constitute most of Piaget's theory of motivation, which is a rather underelaborated part of his psychological system. The organism has a basic need to continue contact with an object as long as adaptation to it is incomplete—or, as Piaget would say, as long as the corresponding schema is in disequilibrium. The need for commerce with an object persists until the child's behavior has been wholly adapted to whatever novelty it presents, that is to say, it persists until the child has acquired mastery. Once accommodation is complete and assimilation is total, the schema is said to be "in equilibrium," and there is no further adaptation. There is, in short, no learning without a problem.

Further, two *schemata* are in disequilibrium until they have mutually accommodated and assimilated, and thereby been integrated into a new superordinate mental structure. This tendency to integrate schemata into more and more complex wholes is assumed by Piaget to be a native propensity of the mind, and as fundamental as the tendency toward equilibrium in physical systems. To put the matter in less cosmic terms, the person strives continually for more and more comprehensive mastery of his world. At each *stage*, however, he is concerned with those things which lie just beyond his intellectual grasp—far enough away to present a novelty to be assimilated, but not so far but what accommodation is possible. Phenomena too simple—i.e., already in equilibrium—

and phenomena too complex for present adaptation are ignored in favor of those in the critical range. Anyone who has ever watched the persistence, and resistance to satiation, of a baby intent on mastering a developmental task—for example, learning to walk—will agree with Piaget as to the strength of the motivation, whether or not he accepts Piaget's thermodynamic metaphor.

What then are the general *stages* of intellectual development, and how may they be characterized? Piaget's stages are one of the best known aspects of his work, but he has not been altogether consistent either in the number of them or in the names assigned. Moreover, the stages are linked to particular chronological ages only rather loosely, and Piaget has himself offered data to show that the age at which a particular stage is reached differs for different content domains. For example, conservation (i.e., invariance under transformation) of a plastic object, such as a lump of clay, is acquired first with respect to mass, a year or so later with respect to weight, and a couple of years after that with respect to volume. Moreover, the Geneva group are concerned to demonstrate the invariance of the *sequence* of stages, not the age at which a given stage is achieved. In Martinique the children are 4 years retarded compared to those in Montreal (Laurendeau & Pinard, 1963), and certain Brazilian Indians appear never to achieve the last stage—but the sequence is everywhere the same.

When Piaget visited Berkeley, he deplored the preoccupation of American psychologists with accelerating a child's progress through the successive stages, and commented on recent work of Gruber, who found that kittens achieve awareness of the permanence of objects in 3 months, the human baby only in 9 months; but the important fact is that the cat never acquires the power to think in terms of formal logic, and the human being may!

The more recent books from Geneva usually divide development into four stages: the sensorimotor, from birth to 2 or 3 years; the preoperational stage, from around 2 to around 7 years; the stage of concrete operations, from roughly 7 years to 11 or 12; and finally the stage of formal operations. Each stage in turn has substages—no less than six for the sensorimotor period alone—which we shall not have time to describe today.

The sensorimotor period as a whole (i.e., from birth up to age 2) carries the child from inborn reflexes to acquired behavior patterns. It leads the child from a body-centered (i.e., self-centered) world to an object-centered one. During this period the various sensory spaces, of vision, touch, and the rest, are coordinated into a single space and objects evolve from their separate sensory properties into *things* with multiple properties, permanence, and spatial relationships to other objects. Altogether this stage comprises a most important set of intellectual achievements.

The preoperational stage (2 years to around 7 years) covers the important period when language is acquired. This permits the child to deal symbolically with the world instead of directly through motor activity, though his problem solving tends to be "action ridden." The child is himself still the focus of his own world, and space and time are centered on him. Time is only "before now," "now," and "not yet"; and space moves as the child moves. When he is taken for an evening walk, the moon follows *him*. Traces of this attitude are present even in adults, who often locate places and things in terms of distance and direction from themselves, rather than in terms of objective spatial relationships. By a process of "decentering," the child during this stage learns gradually to conceive of a time scale and of a spatial world which exist independent of himself. In dealing with physical objects and quantities, the child pays attention to one aspect to the neglect of other aspects. He concludes, for example, that there is more water in a glass graduate than in a beaker—though he has just seen it poured from the one vessel into the other—because in the graduate the column of water is taller, and the child neglects the reduction in diameter.

The stage of concrete operations has its beginnings as early as age 6 or 7. Now the child grows less dependent upon his own perceptions and motor actions and shows a capacity for reasoning, though still at a very concrete level. Among his "logical" acquisitions are classifying, ordering in series, and numbering. Asked to put a handful of sticks in order by length, he need no longer make all the pair comparisons but can pick out the longest, then the longest one left, and so forth, until the series is complete. When shown that Stick A is longer than Stick B, and Stick B is longer than

Stick C, he can infer without actual demonstration that A is longer than C.

Here at Berkeley, my students and I have been developing test materials based on Piaget experiments, and intended to measure the abilities of children in the primary grades. i.e., at the transition point from the perceptual attitude of the preoperational stage to the reasoning attitude of the stage of concrete operations. Thus far, fifteen tests have been developed and administered to more than 300 school children. Although we abandoned the *méthode clinique* for a strictly standardized psychometric approach, we have observed precisely the same types of behavior which Piaget had previously reported.

The last of Piaget's major stages of intellectual development begins usually somewhere around 11 or 12 years and matures a couple of years later. He calls it the stage of formal operations. Now the child can deal with abstract relationships instead of with things, with the form of an argument while ignoring its content. For the first time he can intellectually manipulate the merely hypothetical, and systematically evaluate a lengthy set of alternatives. He learns to handle the logical relationships of Identity (I), Negation (N), Reciprocity (R), and Correlation (C), which permit him to deal with problems of proportionality, probability, permutations, and combinations.

I have just referred to the INRC logical group whose acquisition marks the last stage of intellectual growth. In Piaget's writings over the years, the characteristics of each stage and the differences between them have increasingly been formulated in the notation of symbolic logic—a circumstance which does not increase the comprehensibility of his latest books for nonmathematicians.

Nevertheless, this transition to the language of formal logic is of profound importance for Piaget's theory because it provides a set of explicit, mathematical models for cognitive structure, and serves as a vehicle to describe in a unified way the findings of experiments very different in content. The unity and economy of the logical theory as contrasted with his earlier multiplicity of explanatory terms—egocentrism, syncretism, animism, realism, etc.—is obvious. However, Piaget's critics have sometimes found the mathematical formulation strained, and have accused Piaget of distorting

intellectual development to force it into the categories of formal logic.

Piaget's point of view may have been misunderstood. As he phrases it (1957),

The aim is . . . to study the application of logical techniques to the psychological facts themselves. . . . The question whether the structures and operations of logic correspond to anything in our actual thought, and whether the latter conforms to logical laws, is still an open one. . . . On the other hand, the algebra of logic can help us to specify psychological structures, and put into calculus form those operations and structures central to our thought processes. . . . The psychologist welcomes the qualitative character of logic since it facilitates the analyses of the actual structures underlying intellectual operations, as contrasted with the quantitative treatment of their behavioral outcome. Most "tests" of intelligence measure the latter, but our real problem is to discover the actual operational mechanisms which govern such behavior, and not simply to measure it [pp. xvii-xviii].

Many psychologists who acknowledge the brilliant originality of many of Piaget's experiments, and the enormous importance of his empirical contribution taken as a whole, continue nevertheless to reject the formal, mathematical theory which lies closest to Piaget's heart. Yet one of the most impressive parts of Piaget's discussions here in Berkeley concerned the isomorphism between his stages and the most basic structure of mathematics itself.

Piaget points out that if one considers not the content, but the architecture, as it were, of the various branches of mathematics, one discovers first a level where the prototype structure is the group and the type of reversibility is inversion or negation. Next comes a level where structures of order, such as the lattice, are typical, and reversibility is not inversion but reciprocity. Last comes the level of topology with key concepts of neighborhood, boundary, etc. Now the first of these three levels is the oldest, one part of it, Euclidean geometry, going back to the Greeks. The second level, typified by projective geometry, dates from the late seventeenth century; and the last, or topological, level is a product only of the nineteenth century. Taken in sequence, each level is more general, i.e., involves *fewer* axioms than the preceding, and the entire sequence might theoretically be expected to have developed in the opposite order. Now the curious part, is that the sequence of acquisition of mental operations by children follows not the historical sequence, but

the theoretical sequence. Small children of 3 years of age, who for example are quite unable even to copy a simple geometrical figure such as a square, have no difficulty differentiating between a closed figure like a circle and an open one like a cross, and they can easily follow instructions in putting a second circle, however imperfectly drawn, inside, or outside, or even half in and half out of the experimenter's circle. Further evidence of young children's grasp of topological principles is seen in their sure knowledge of the forms into which a sphere, such as a balloon, can be deformed—i.e., sausalike, flat sided, or dimpled figures, etc.—and those forms such as the torus or doughnut, which cannot be obtained by deformation of a sphere. Later, with the shift from the preoperational stage to the stage of concrete operations at age 6 or 7, the child learns to handle relations of order—seriation, transitivity, reciprocal relationships, and the rest to which I have already referred. Only with the approach of adolescence does he spontaneously utilize the propositional algebraic structures which are the oldest development in the history of mathematics.

What finally are the implications of Piaget's work for fields other than psychology and mathematics? Certainly they have a major bearing upon education.

If Piaget is correct—and much work now substantiates his empirical findings at least in broad outline—methods of education will be most effective when they are attuned to the patterns of thought which are natural to a child of the age concerned. It may not be true that you can teach a child *anything* if your approach is correct, but it does look as if you can teach him a great deal more than anyone might have guessed. Of course, teachers long before Piaget recognized intuitively that a child learned better when problems were approached at a concrete rather than at an abstract level. But there is more to it than that. Bruner, at Harvard, and others in this country are attempting to find ways to introduce children to some of the abstract ideas of mathematics—for example, the algebraic concept of squaring a number—by concrete, geometric models. They hope thus possibly to accelerate a child's progress—a goal which Piaget has his reservations about. Perhaps the most dramatic evidence of a revolution which owes a great deal of its impetus to Piaget

is the new elementary school mathematics, in which children even in the lower grades are being taught, and learning, and actually enjoying learning basic arithmetical and geometrical ideas introduced via set theory, which most of their parents have never heard of.

I could not better conclude this appreciation of Piaget than by quoting from William James (1890) who wrote 75 years ago in his famous *Principles of Psychology* as follows: "To the infant, sounds, sights, touches and pains form probably one unanalyzed bloom of confusion [p. 496]." We can now go beyond the philosopher's speculations and describe in some detail how the unanalyzed "bloom of confusion" of the infant becomes the world of the child—in which not only objects, but time, space, causality and the rest acquire a coherent organization. And we owe this achievement in large measure to the analyses of Jean Piaget.

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