THE CONCEPT OF EQUILIBRATION IN PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

by

MARGARET RUTH SUTTON
B.A., Seattle University, 1974

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in

THE FACULTY OF GRADUATE STUDIES
(FOUNDATIONS OF EDUCATION)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
April, 1978

Department of Educational Foundations

The University of British Columbia
2075 Wesbrook Place
Vancouver, Canada
V6T 1W5

Date April 28, 1978

ABSTRACT

Many philosophers and psychologists have questioned the meaning and/or function of the concept of equilibration in Piaget's theory of cognitive development. It is argued here that a) the concept of equilibration is distinct from other, similar concepts in Piaget's theory b) that the particular character of equilibration as a mechanism of self-regulation allows Piaget to account for the differences between biological and cognitive structures and c) that equilibration is therefore a fruitful concept in Piaget's theory of cognitive development.

Chapters One to Three are a presentation of the problem, and a synopsis of Piaget's theory of genetic epistemology and model of organic structures. Chapter Five lays out the criteria by which equilibration could be said to be a fruitful concept. Chapters Six to Eight examine the rôle which equilibration plays in Piaget's theory. In Chapter Nine, it is concluded that equilibration is a fruitful concept in Piaget's theory, and some general points about the theory are discussed.

LEAF iii OMITTED IN PAGE NUMBERING.

ACKNOWLEDGEMENTS

I would like to thank my thesis committee, Drs. Jerrold Coombs, LeRoi Daniels, and Gaalen Erickson as well as other faculty members, particularly Dr. Patricia Arlin, for their criticisms and suggestions. Warm thanks also to the many department members, especially Shirley Packinson and Andy Gingera, who have provided counsel and encouragement throughout the writing process, and to Sheilagh Crandall, for her assistance in preparing the final copy.

TABLE OF CONTENTS

LIST OF CHARTS

I. STATEMENT OF THE PROBLEM

"Equilibration" is a word which has become increasingly prominent in Piaget's work. At the same time, it is not easy to tell from his works just what equilibration is. He speaks of "equilibration factors of action"[1], "equilibration laws"[2], "equilibration processes"[3] and the "mechanism of equilibration".[4]

Various psychologists and philosophers have commented upon equilibration, also in diverse terms. Furth speaks of equilibration as "...a regulatory and organizing factor within evolutionary development"[5]. Mischel proposes that equilibration be considered as "...an analysis or rational reconstruction of how we think in accordance with the norms that govern directed thinking."[6] Elkind, in his introduction to Six Psychological Studies, says that:

> The principle of equilibration which regulates the interaction of social and maturational factors is essentially dialectical in nature.[7]

Perhaps the questions surrounding equilibration are best summed up by Flavell, when he says:

> I am even unclear as to exactly what phenomenon equilibration is and is not supposed to denote.[8]

a) Questions Concerning Equilibration

Since equilibration is a hypothetical construct in Piaget's theory, there are several questions involved in examining its meaning. The first question is "What does Piaget mean by 'equilibration'?" Related to this question, we also want to know how equilibration operates in Piaget's theory. And because, it will be argued, equilibration is meant to explain or describe certain features of cognitive development, we will also ask whether equilibration is a fruitful concept for these purposes.

b) Method of Approach

Equilibration is a particularly theory dependent concept. It is defined in terms of the theory of which it is a part, which Piaget calls "genetic epistemology". The purpose of the concept of equilibration is to add to the account of development provided by genetic epistemology. Further, the reasons for believing that there is a mechanism of equilibration are derived from the theoretical body.

Equilibration, then, cannot be isolated from the theory of which it is a part. Its meaning must somehow be clarified in terms of the role which it plays in Piaget's account of cognitive development. For this reason, Chapters Two through

Four will be devoted to a brief exposition of Piaget's theory of cognitive development. Chapter Two will be an overview, focusing on the factors of cognitive development. In Chapter Three we will look at structuralism, asking what Piaget means by a structure. Chapter Four will be an account of structuralism applied to cognitive development. Here we want to establish what Piaget is explaining about cognitive development, and how he purports to do so.

In Chapter Five, we will turn to the question of what it would mean for equilibration to be a fruitful concept in Piaget's theory. Determining the fruitfulness of equilibration depends in large part on establishing how equilibration differs from other regulatory mechanisms, and the reasons for believing that it does are seen in the differences between cognitive structures and biological structures. So, in Chapter Six we will look at different mechanisms of self-regulation, and in Chapter Seven, at the way in which cognitive structures are constructed. In Chapter Eight, we will ask how a particular mechanism of the sort that Piaget describes accounts for the construction of logico-mathematical structures. Finally, in Chapter Nine, we will discuss whether the concept of equilibration is fruitful to Piaget's theory.

II. OVERVIEW OF PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

According to Piaget's theory of cognitive development, the subject passes through three levels of cognitive development - sensori-motor, pre-operational, and concrete operational - before reaching the final stage, of formal operational thinking. By "stage" Piaget does not means groups of action characterized by some theme, as does Freud, for example. Rather, Piaget puts forth three conditions for calling something a stage of cognitive development:

> ...first, the series of actions is constant... second, each stage is determined not merely by a dominant property, but by a whole structure which characterizes all further actions that belong to this stage third...these structures offer a process of integration such that each one is prepared by the preceding one and integrated into the one that follows.[9]

The first condition says that the order of the stages is invariable, although the age at which each stage is attained can vary according to the individual. The second condition is that a stage constitute a structured whole (there will be a discussion, below, of Piaget's meaning of "structure"). The third condition gives Piaget's definition of development. Development is more than a change from one organization to another; the change must be a re-organization of the previous structure, so that the new structure includes all that went before it. Each stage is a necessary condition for the next, with biological organization providing the initial conditions for sensori-motor structures. In his many observational studies of children's thought, Piaget makes the case that there is a process of cognitive development, which proceeds through stages of the sort that he defines. His observation that children go through particular stages of cognitive development, and that the order of these stages does not vary, have been corraborated by other researchers.

a) <u>Factors of Cognitive Development</u>

Piaget has named four factors which determine cognitive development; maturation, physical experience, social experience, and equilibration. Maturation is the unfolding of predetermined structures, i.e. growth and development necessitated by the individual's genetic code. Physical experience refers to experience of a more or less individual nature, though many of the experiences are common to all people. Included would be such actions as manipulation of objects and movement through space. Social experience is the interaction of the individual with her social environment, i.e. the intersubjective world.

These first three factors, taken either independently or in sum, do not explain the universality and invariance of cognitive development. There is to begin with the difficulty of separating them from each other, in order to determine their unique contributions. Even if it were possible to do so, through advances in technology and formalization, the question would not be answered. It is unlikely that maturation alone can account for individual differences, e.g., in the speed of development. The varieties of physical and social experiences of each individual make them unlikely explanations for a process common to all individuals. And, if all three factors taken together are to explain cognitive development, there is still the question of how they relate to each other, i.e., determining their respective contributions to the process.

Because the classical factors fail to account for cognitive development, Piaget postulates a fourth factor, equilibration. Equilibration enables us to determine the roles of the other three factors in cognitive development, and to account for the pattern of cognitive development. Equilibration processes, Piaget argues,are intrinsic to human life, and in that sense, hereditary. They are process of internal regulation, which determine the effects of experience on cognitive development. The existence of internal regulations of the sort defined as "equilibration" account for the particular process of development which Piaget has observed.

b) Equilibration

Equilibration is a process of achieving equilibrium. Equilibrium is a state of balance. What are somehow balanced, in Piaget's system, are structures. Structures are a particular kind of organization. Among other characteristics, structures are by definition dynamic. They are properly understood in terms of their processes of formation and maintenance, rather than in their states. The processes of formation and maintenance are guided by internal mechanisms of regulation. Equilibration is the internal regulatory mechanism which determines cognitive development.

In order to understand how equilibration regulates cognitive development, we must know what Piaget considers to be cognition. One of the characteristics of cognition is that it is active. Piaget claims both conceptual and empirical links between cognition or knowing, and activity or action. On the empirical plane, he points out that the organism is biologically active, never simply a receptor of environmental stimuli, and asks:

> But are we to believe that an organism which is active at every stage of growth should, upon reaching the apex of its development, become a mere slavish imitator of its surroundings?[10]

We do not merely receive or react to our environment, we interact with it, cognitively as well as biologically.

On the conceptual level, Piaget claims that to know something always implies activity of some sort: "...any piece of knowledge is connected with an action...to know an object or happening is to make use of it by assimilation into an action schemata".[11] Action can mean anything from a physical activity such as removing the cover from a hidden object, to the mental activity of cognitive organization, such as assimilating new information into pre-existing schemata. Cognition is always active because knowing always involves some type of organization.

Equilibration regulates structural activity in two ways. First, it determines the form that cognitive organization takes, at each stage of cognitive development. The form of organization in turn determines the activity possible. Second, equilibration regulates the effects of structural activity on the structures. This point will be elaborated in Chaper Six. In both cases, regulation is a process of establishing a balance between repeating an extant form of action, or structure, and modifying structure.

III. STRUCTURALISM

Piaget sees cognitive development, then, as a process of structural development. He uses biological structures as the source of a model with which to understand cognition. The applicability of this model to cognition rests on two points: 1) that we can identify structures of cognitive activity which are analogous to organic structures and 2) that these structures originate in biological activity. The latter point will be taken up in Chapter Four (b). In this chapter, we will look at the properties and functioning of structures based on such an organic model.

a) Properties of Structures

A structure is a dynamic entity, whose components can change, but which remains organized throughout such changes. Piaget says:

> We shall define structure in the broadest possible sense as a system which presents the laws or properties of a totality seen as a system. [12]

The three properties of structures are wholeness, transformation and self-regulation.

Wholeness refers not to the sum of the parts, but to the relationship of the parts with each other. Four line segments do not make a square; four equal line segments joined at right angles at their endpoints do. The particular line segments are not necessarily related to the structure of a square. It is their relationship with each other, i.e., equality of length and joining at right angles, that constitute the structure. These relationships are the "laws of composition" of a square.

The example of a square is slightly misleading in that Piaget is speaking of "larger" structures, structural systems. The example is used to point out that it is the laws of composition which define a structure. These laws of composition not only determine the relationship of the parts, but: "...they confer on the whole as such overall properties distinct from the properties of the elements".[13] Piaget uses the example of integers, which are necessarily ordered. This ordering confers on integers as a whole structural properties, such as reciprocity, which are distinct from the properties of individual integers, such as evenness or oddness. Since a structure consists of its laws of composition, rather than simply its elements, wholeness is a property of the laws. "Wholeness" thus is primarily contrasted to "aggregation".

The wholeness of a structure also includes the ability of the laws of composition to cope with or compensate for "intrusions" upon it, or changes in the environment of the structure. Thus rather than being complete or incomplete, a structure is more or less "adequate" or "stable". A structure is in a state of equilibrium when, without transformation of its compositional laws, it can maintain itself against intrusions. This equilibrium must be dynamic, since it is always subject to new disturbances from the environment.

The second property of structures is transformation. Piaget speaks of transformation in two related senses. First, it is a property of structures to "transform" portions of the environment by structural activity. This simply means that structures incorporate external elements into themselves. For example, the digestive system "transforms" a piece of bread into carbohydrates, fatty acids, and amino acids. Besides transforming the environment, structures have a property of transforming themselves. By this Piaget means that the laws of composition can change. For example, if we treat the historical development of mathematics on an organic model, we see that the system of rational numbers cannot incorporate the relationship of the hypotenuse of an isosceles right triangle to its sides. Since the rational number system cannot incorporate this relationship, something which is not a rational number, and which can express this relationship is created, the irrational number. The compositional laws of the entire number system change with the introduction of irrational numbers, e.g., numbers can now incorporate infinite processes. Note that within this organic model, the compositional laws are never falsified or destroyed in transformation; the "untransformed" laws become a subset of the "new" laws of composition.

These two senses of transformation are conceptually related by definition of the laws of composition. The laws of composition determine the kinds of elements which can be incorporated into the structure. The laws of composition also contain the potential for their transformation.

> These laws must of their very nature be structuring...a structure's laws are defined 'implicitly' i.e., as governing the transformations of the system which they structure.[14]

Because the mechanism for transformation of compositional laws is implicit to the laws, this kind of transformation is called self-transformation.

The idea of self-transforming laws does not lead to an infinite regress. Some structure must exist in order to even talk of compositional laws. Life implies organization, and therefore structure. In the case of cognitive structures, Piaget takes the biologically determined organism, the genotype, as the structure constituting the laws of compostion from which cognitive structures are formed.

It is the third property of structures, self-regulation, which determines that changes in a structure constitute development, rather than some haphazard series of transformations. Self-regulation, Piaget states, entails selfmaintenance and closure. Together, these properties provide that "the transformations inherent in a structure never lead beyond the system but always engender elements that belong to it and preserve its laws".[15] Self-regulation is first of all conservative. In the face of environmental intrusions, including decay over time, the wholeness of a structure is maintained by self-regulation. For example, where the left hemisphere of the brain has been damaged, some of its functions are taken over by the right hemisphere. The brain brings previously unused circuits into play in order to conserve total functioning.

By maintaining the organization of a structure, self-regulation provides for the development of new and more adaptive structures. Transformation provides the potential for new constructions; self-regulation incorporates these new constructions into the existing structure. By reintegrating new structures into the original structure, self-regulation is constructive. If, for example, an individual acquired a system of irrational numbers that remained independent from a system of rational numbers, the number system would not have undergone development, although we could certainly say that a new structure had been constructed. For the new structure to be incorporated into the old, the old structure must be reorganized to enable it to encompass properties of both structures. This is how self-regulation is constructive beyond the limits of transformation. In regulating transformations, self-regulation constructs structures with differentiated substructures.

b) Functioning of a Structure

Piaget describes function in terms of the inherent action tendency of a structure. For example:

> Function is the action exerted by the functioning of a substructure on that of a total structure, whether the latter be itself a substructure containing the former or the structure of the entire organism.[16]

There are two major categories of organic functions: adaptation, which can be divided into assimilation and accommodation, and organization. When a disturbance is compensated for by repetition of an extant pattern or substructure, this is called assimilation. The disturbance is subsumed by the structure. Inhaling is an example of a biological assimilatory function. The lungs, which are a substructure of the total organism, respond to a disturbance, in this case, an internal need. By repeating the coordinated action of inhaling, the lungs compensate for lack of oxygen in the blood stream by bringing it into the system. Accommodation is the reverse of assimilation, where a disturbance to the structure is compensated for by alteration in a substructure. It would be nice to say that exhaling is an example of accommodation, but it is not. Accommodation is a change in assimilation structures in response to the environment. Piaget provides an example:

> ...in an infant of five or six months old, the seizing of things by both hands is an assimilation schemata, but the stretching out or bringing nearer of the hands according to whether an object is near or far is an accommodation of that schema.[17]

The second category of organic functioning is called organization. Whereas adaptation functions operate on the structure's environment, organization functions operate on the structure itself:

> ...of a function may be said to be the action exerted by the functioning of a substructure on that of the total structure...organization as a function is the action of the entire functioning on that of the substructures.[18]

Both types of functioning are mechanisms of self-regulation. Adaptation functions maintain structural integrity in the face of environmental intrusions. Organization functions maintain structural organization when it is threatened by internal disturbances. These "internal disturbances" are the aftermath of accommodations. An accommodation constructs a new substructure. The new substructure must be either reintegrated into the original structure, or lost. This reintegration is the organizing function.

IV. APPLICATION OF STRUCTURALISM TO COGNITIVE DEVELOPMENT

Discussion of an organizing function raises a question which pervades Piaget's works. In this case, it is "Which comes first, organization of structures, or organizing functions?" In more general terms, the question is, "Are structures a product of functioning, or are functions a product of structures?" It is first of all apparent that there cannot, by definition, be functioning without a structure. At the same time, structures cease to exist without functioning. Functioning, above all, maintains or conserves structure. Piaget's essential hypothesis is that, in the activity of conserving structure, functions are constructive. If this is so, the formation of new structures is determined by the functioning of (temporally) prior structures. Since functions are mechanisms of self-regulation, the particular way in which a function regulates is a key determinant of the structures which can be constructed.

a) Structuralist Explanation of Cognitive Development

In the area of cognitive development, Piaget wishes to explain the construction of logico-mathematical structures. Two aspects of this construction must be explained, the process and the result. In the first case, we wish to account for the universal and invariant sequence of development. In the second case, what must be accounted for are the special structural properties of logico-mathematical structures.

These questions are connected by the hypothesis that functioning constructs new structures. The distinct character of operational thought can be explained in terms of cognitive functioning. Cognitive functioning can be thought of in terms of its similarities to and differences from biological functioning. These similarities and differences are explained by equilibration, the internal regulatory mechanism of cognitive functioning.

Piaget claims that cognitive structures develop in like manner to, and continously from, biological structures: "...intelligence constitutes an organizing activity whose functioning extends that of the biological organization, while surpassing it due to the elaboration of new structures".[19] The key to the argument for the continuity from biological to cognitive structures is the generalization of functions. Initial biological organization provides functioning. Functional generalization elaborates upon prior structures, creating specialized structures which in turn provide increasingly specialized functioning.

b) <u>Transition From Biological to Cognitive Functioning</u>

Piaget maintains that his model of biological functioning is more than a metaphor by which to understand cognitive development. Cognitive functioning, he maintains, is an extension of biological functioning. In The Origins of Intelligence,[20] Piaget traces the development of the first cognitive structures, from reflexes programmed by biological regulations. Repetition and coordination of reflex functioning form schemata for habits. As these habits are refined by functioning, the possibliities for formation of "truly cognitive" structures are increased.

Piaget defines cognitive activity as intentional action, action which distinguishes between means and ends. He states that it is difficult to draw a clear line between primitive forms of intentional action and biologically determined actions but:

> In practice, we can acknowledge...that intentional adaptation begins as soon as the child transcentds the level of simple corporal activities (sucking, listening and making sounds, looking and grasping) and acts upon things and uses the interrelationships of objects.[21]

In his accounts of the transition from biological to cognitive functioning, he focuses more on how this transition occurs, e.g., describing the transition in structuralist terms, than why it occurs, e.g., what cause the transition. Briefly stated, the increasingly complex adaptations, providing a series of functions to attain one end, "bring attention to" the difference between means and ends.

A series of increasingly complex adaptations of instinctive functioning lead to the "bursting of instinct", which is the creation of structures which are not maintained by programmed, or genetically determined, functioning. Instead, the structures of cognition are maintained by internal mechanisms of self-regulation. Cognitive functioning does not destroy or replace biological functioning, but extends it:

> What vanishes with the bursting of instinct is exclusively the central or median part, that is, the programmed regulation, whereas the other two realities persist: the source of organization and the resultants of individual or phenotypic adjustment. Thus, intelligence does inherit something from instinct although it rejects its method of programmed regulation in favour of constructive autoregulations.[22]

The mechanism of constructive autoregulation, is what Piaget calls equilibration.

V. EQUILIBRATION AS A HYPOTHETICAL CONSTRUCT

In light of the previous sections, we can now formulate a general definition of equilibration: equilibration is the mechanism of cognitive self-regulation. As a structural self-regulatory mechanism, it both conserves structural organization, and constructs new structures. While it has its early origins in biological functioning, equilibration must transcend the limits of merely regulating structures.

Functioning of cognitive structures must be capable of not only responding to the environment, but adapting to it. That is, the notion of growth or the construction of cognitive structures cannot be limited to the innate potential contained within genetically given structures themselves, as is the case with biological structures. So, equilibration differs from biological autoregulations. The differences between biological autoregulations and equilibration can be seen by the differences between biological and cognitive structures. Because equilibration constructs structures, it explains the necessary pattern of cognitive development, and the unique stability of logico-mathematical structures among organic structures.

a) Meaning

This definition of equilibration is based on the relationship of concepts in Piaget's model of organic development. Structures have a property of self-regulation. Self-regulation is maintained by mechanisms of regulation, or regulatory mechanisms. Since differenct types of structure have different mechanisms of regulation, cognitive regulatory mechanisms differ from biological mechanisms. The definition is, however, very general at this point. To say more specifically what Piaget means by equilibration, it is necessary to examine in more detail the differences between cognitive and biological structures, and between cognitive and biological functioning.

b) Fruitfulness

Since equilibration is a hypothetical construct in Piaget's theory, it is postulated for a purpose. The purpose of the equilibration construct is to account for some features of cognitive development. Thus, in examining the meaning of equilibration, it is pertinent to ask whether equilibration is a fruitful construct in Piaget's theory. There are three ways in which equilibration could be said to be fruitful in the theory. The first is that it is a necessary and useful concept for providing an internally coherent theory. The second way in which it could be fruitful is for it to suggest experiments or procedures for examining cognitive development. The third way in which equilibration could be a fruitful construct is for its postulation to enable Piaget's theory to predict or retrodict aspects of cognitive development.

The first type of fruitfulness has already been addressed. By definition of the concepts in Piaget's organic model of development, cognitive structures require a specialized mechanism of self-regulation. The equilibration construct holds together less abstract concepts, such as functioning and structural change.

Piaget does not deal in depth with the second form of fruitfulness. Most of his work on equilibration concentrates on specifying the exact nature of the equilibration mechanisms. To date, most of his procedures for examining cognitive development have only depended upon understanding cognitive development as a series of constructions, and have not depended upon specifying the particular mechanism of construction. He does note, however, the work of some of his associates in this regard.[23] They have looked at the learning which takes place at particular points in time when a subject would be "disequilibrated" according to Piaget's definition of equilibration.

It is the third form of fruitfulness which will be most explicitly examined in the following pages. We wish to establish the point that postulating a particular self-regulating mechanism in the form of equilibration allows Piaget's theory to predict and retrodict, or account for, cognitive development. It should be noted that the question of fruitfulness of this type is connected to the first type of fruitfulness. That is, we must ask whether equilibration is necessary for the model developed by Piaget.

VI. BIOLOGICAL AND COGNITIVE SELF-REGULATION

In Chapter One it was shown that Piaget considered equilibration to be a distinct factor of development which overrides the three classical factors of maturation, social experience and physical experience. Equilibration is postulated because the classical factors are insufficient alone to account for cognitive development. They do not, and Piaget argues, cannot explain how formal operations are formed. For this reason, he concludes that there must be a fourth factor which coordinates the other three.

The three classical factors are subsumed into a model of organic development (biological functioning) which provides a good analogy for cognitive development. That is, the interpretative account of observations concerning cognitive development given by this model is plausible and comprehensive. Further, Piaget has provided an explanation of the direct transition from biological functioning to cognitive functioning. This simultaneously gives credence to the biological model, and further elaborates upon it. However, the structures constructed by cognitive functioning, especially the structures of formal operations, differ from biological structures. Equilibration must differ from biological autoregulation, in order to account for the differences between biological and cognitive development. By analogy to the biological model, equilibration is a mechanism of internal regulation, which develops from biological functioning, and which in turn determines cognitive development. In order to determine the role which "equilibration" plays in Piaget's theory, we need to know a) what self-regulatory mechanisms are and b) how equilibration differs from biological autoregulations.

a) Self-regulation by Functioning

Self-regulation is given as a property of structures. If a system were not self-regulating it would be either an inorganic form, or dead or dying. But the property or self-regulation is not the same as a mechanism of self-regulation. There can be any number of mechanisms which account for the property. Functions, in Piaget's theory, are autoregulators. Structure is conserved by functioning, by structural activity. Besides structural self-regulation, there can also be functional self-regulation:

> Structural regulation is that which occurs when the modification brought about is either anatomical or histological, whereas functional regulation has an influence only on the exercise of physiological reaction of the organs.[24]

Although functional regulation ultimately conserves structure, it does so by regulation of functioning, not by structural compensation.

Functions, and groups of functions linked in feed-back systems, form one type of autoregulatory mechanism. These regulators conserve structure. Regulation of functions themselves would require specialized substructures, or "organs" of regulation.

Piaget points out that the only clear example of a biological structure which is a functional regulator is the nervous system. Through the nervous system, various functions of the body are regulated in response to either internal or external disturbances. Most functional regulators, as conceived in Piaget's theory, are themselves second (or higher) order functions, postulated to enable the theory to give a fruitful account of human behaviour.

Piaget describes the genesis of functional regulators as a process of increasing differentiation and reintegration of substructures from the original structure. Cognitive structures, he maintains, are constructed as specialized structures of functional regulation which are differentiated from the nervous system:

> Cognitive processes seem, then, to be at one and the same time the outcome of organic autoregulation, reflecting its essential mechanisms, and the most highly differentiated organs of this regulation at the core of interactions with the environment... [25]

Cognitive structures are extrapolated from biological functioning, and especially from functioning as autoregulation. Autoregulations, freed from physical structure, are coordinated into cognitive structures. Logico-mathematical structures are structures of functioning. The coordination of these structures of functioning requires a specialized mechanism of autoregulation, which Piaget calls equilibration.

Just as the nervous system regulates biological functions in their interaction with the environment, equilibration regulates cognitive functioning in its interaction with the environment. Functional interaction with the environment Piaget calls "exchanges", and when these exchanges are cognitive, they are called "behavioural exchanges". Regulated functioning involves an exchange, because the functioning affects the environment, which in turn affects functioning. Cognitive activity is "behavioural", not as distinct from intentional action, but from biological functioning.

Equilibration, then, is distinct from most biological regulation because it regulates function rather than structure. The nervous system, however, is one exception since it is a functional regulator. We can ask now whether equilibration is a distinct self-regulatory mechanism, or whether it is simply an extension of regulations of the nervous system. Piaget has discussed in great detail the problems involved in structural and functional comparison.[26] All structures are similar in a general sense, that is, insofar as they have the properties which define them as structures. Similarly, all kinds of structures can have parallel functions, since functions are defined by the type of action exerted upon the structure. There are, however, ways of distinguishing and comparing structures. They can be distinguished on the basis of their elements, their laws of composition, and by different types of laws of composition. And, insofar as structures differ, their functioning is distinct from that of other structures.

b) Regulation of Cognitive Structures

Cognitive structures differ from biological structures, the differences increasing with each stage of cognitive development. One of the chief differences between cognitive and biological structures and thus, cognitive and biological functioning, is seen in the different environments in which they operate. Since all types of regulated functioning are exchanges with the environment, different environments indicate different structures. The environment of biological structures is relatively well-defined, and stable over time. The environment of the liver, for example, can be affected by externally introduced elements, but remains nonetheless essentially stable: the rest of the body. The nervous system, of course, operates in a much more fluid and complex environment than the internal organs. Still, its potential for changing its environment is limited, so the environment itself is limited.

The environment of cognitive structures, on the other hand, is constantly expanding. The cognitive subject in the sensorimotor stage operates in an environment defined by biological functioning, instinct, habit and the possibilities for action accorded by subject/object differentiation. This differentiation alone creates a marked distinction between the environment of the young child and that of an essentially instinctual animal. The subject/object differentiation is the beginning of a disassociation of form and content, form in this case meaning a pattern of action (schema), and content, the object being manipulated. Later in development, "content" is abstracted from material objects, and the environment which the subject operates expands to include non-material objects. In the formal operational stage, the cognitive subject affects, and is affected by a variety of objects spatially and temporally removed from her.

The expanding environment of the cognitive subject indicates several things about cognitive structures. First, as there are non-material objects, such as numbers, or properties of material objects, the manipulation of these objects is not necessarily a physical action. Schema can be non-physical, and in this sense, "internalized" actions. This of course makes it difficult to identify something as a schema. Second, the expanding environment indicates the enormous potential for development of cognitive structures. Structures are built through exchanges with the environment, the existing structures defining the environment at that point, and the exchanges modifying and building new structures, which open up new possibilities for action. Third, the very potential for action is an enormous menace to the stability of cognitive structures. A relatively stable environment may not be very exciting, but it does pose only a limited number of threats to a structure's organization. The complex and expanding environment of the cognitive subject generates problems to be resolved.

For all structures, self-conservation means conserving organization in the face of environmental intrusion. Cognitive structures, which actively produce intrusions, require increasing organization in order not to be destroyed by their own functioning. Each of the stages of cognitive development identified by Piaget represents an increasingly stable organization of cognitive structures. In fact, the final stage of development identified by Piaget, logico-mathematical thought, is stable to an extent unique among organic structures:

> We suggest that the equilibrium...which is brought about by logico-mathematical structures constitutes a state - mobile and dynamic, and, at the same time stable - aspired to unsuccessfully by the succession of forms, at least where behaviour forms are concerned, throughout the course of the evolution of organized creatures.[27]

Not only do cognitive structures conserve organization in the face of an expanding environment, but in so conserving themselves they achieve a highly stable, though always dynamic, form of organization.

In the final stage of cognitive development, the stage of formal operational thought, the striking feature of cognitive structures is their complete reversibility. Operations are:

> Actions characterized by their very great generality... they are also reversible...(and) are never isolated but capable of being coordinated into overall systems.[28]

An action upon an object, such as combining red and blue beads into the class of beads, is reversible because it can be "undone"; the objects can be returned from the class of "beads" to the classes of "red beads" and "blue beads". Logico-mathematical structures, whose functions are operations, are highly stable because:

> ...an operation is a "perfect" regulation. What this means is that an operational system is one which excludes errors before they are made, because every operation has its inverse in the system...or, to put it differently, because every operation is reversible, an 'erroneous result' is simply not an element of the system (if $+n-n \neq 0$, then $n \neq n$).[29]

Logico-mathematical structures are stable in the face of an expanding environment because they form "closed systems". Intrusions upon them are dealt with, without threat to the compositional laws of the structure. Environmental elements are either assimilated or rejected.

Piaget argues that the development of such stable structures requires autoregulations distinct from biological autoregulations.

Biological autoregulations incompletely conserve structure; the structures are still subject to decay over time. Logico-mathematical structures, however, are perfectly conserved, once formed. New information is subsumed by the structures without change in its compositional laws.

By comparing certain characteristics of cognitive and biological structures, Piaget deduces equilibration from the conceptual framework of structuralism. The differences between cognitive and biological structures implies a difference in functioning. In particular, the stability of cognitive structures, which exist in an expanding enviroment, implies a form of self-regulation which more completely conserves structure than does biological functioning. What would yield better regulation than functioning would be a regulator of functions. The regulation of functions is not an intrinsic property of functioning, so cognitive structures must have an additional mechanism by which this functional regulation is obtained.

VII. CONSTRUCTION OF COGNITIVE STRUCTURES

That there is a special mechanism of cognitive regulation, and that it is a functional regulator, is indicated by comparisions of cognitive and biological structures. But if logico-mathematical structures show characteristics of functional regulation, the question remains:

> ...if it is the structures which explain equilibration, or if on the contrary the structures can be interpreted as the product or result of a process of equilibration.[30]

Unless it can be shown that equilibration contributes to the creation of logico-mathematical structures, "equilibration" is not a very fruitful concept in Piaget's theory. To address the issue of equilibration's explanatory usefulness, we must look at the mechanisms of structural construction.

Before examining equilibration's role in the construction of cognitive structures, there must be reason to believe that these strucutres are indeed constructed in some manner. Piaget's evidence for this, of course, is his observation that there are distinct stages of cognitive development. Piaget's enumeration of stages has been modified over time, but is is safe enough to name the three major periods of cognitive development: sensori-motor thought, pre-operational thought, and formal operational thought. Within each of these periods, there are sub-periods and stages. Evidence of the stages consists in observations of distinctive action patterns seen at different points in a child's development. It has been observed by Piaget, and many others,[31] that the presence and order of succession of the stages is constant across cultural barriers, though the speed of succession may vary.

Each stage represents a more or less permanent equilibrium (or "equilibrated state" - to emphasize the active nature of the equilibrium). Piaget's fundamental hypothesis concerning cognitive development is that it is a process of construction of "progressively adequate equilibration",[32] or increasingly stable structures. This process of construction:

> ...in being constantly regulated by equilibration requirements, (a self-regulation whose conditions become the more stringent as it steers toward an equilibrium that is mobile and stable at the same time), finally yields a necessity that is a non-temporal, because reversible, law.[33]

So, equilibration itself is a process; a process which directs the pattern of cognitive development.

In order to decide whether equilibration does, in fact, determine the course of cognitive development, two points deserve special attention. The first is the meaning of cognitive equilibrium. If equilibration is a process of constructing increasingly stable structures, in what sense is a structure more or less stable? The second point concerns the nature of regulatory mechanisms in general, and the differences between equilibration and other regulators. Here we will look at the regulations produced by biological functioning and why Piaget maintains that they alone are insufficient to construct logico-mathematical structures.

a) Meaning of Cognitive Equilibrium

Cognitive structures can be equilibrated[34] in different ways. The first type of equilibrium is a balance between assimilation and accommodation. Assimilation, it will be recalled, is the functioning of a schema, "...to incorporate outside elements compatible with its nature into itself,"[35] and accommodation is the modification of an assimilation schema to deal with a particularity of the environment. To conserve the total structure of a schema, each accommodation must be assimilated to the structure of which it is an accommodation. For example, a schema for putting objects in the mouth could be subject to many accommodations, e.g., taking into account the shape or weight of an object. If each of these accommodations were not assimilated into the schema upon which they were based, there would be no systematic extension of the child's ability to bring objects to the mouth. Instead, each performance of this action would require random trial and error. The process of equilibration as it relates to a balance of assimilation and accommodation is one of assimilating each accommodation to the schemata.

The second form of cognitive equilibrium is an equilibrium between substructures. Various schema can exist independently from each other, and only be brought to play individually. This is the case in Piaget's observations of conservation notions (or lack thereof) in pre-operational thought. A child at this stage might sometimes say that there is more water after it has been poured, because the water level is higher, or that there is less because it is thinner. By reciprocal assimilation of the two schemata, conservation of continuous quantity is constructed. The process of equilibration between substructures is one of mutual intercoordination.

The third form of equilibration establishes hierarchical connections between structures and substructures. In this process, the substructures created by accommodation are reciprocally intercoordinated with their total structure. A structure where all relationships between it and its substructures has been established is a closed system. When such a structure meets with an environmental intrusion, the intrusion is compensated for without change in the compositional laws of the structure.

Cognitive equilibrium is not a "balance" like that between two objects of equal weight on a scale. What is being balanced, instead, are the "forces" of assimilating the environment and accommodating to it. The equilibrium is dynamic because the subject is active. If we said that a subject was in a state of cognitive equilibrium, this equilibrium would be temporary, and would "...consist of a set of probable compensations of external intrusions by the activity of the subject".[36]

Compensations are formed through the functioning of schemata, and are of two types:

> ...the compensations by 'inversion', which are cancellations of the disturbance, and the compensations by 'reciprocity', which are modifications of the schema to accommodate it to the initially disturbing element.[37]

Hammering a nail straight into a piece of wood can involve both types of compensations. Striking the nail on the side compensates for a blow which has bent it down. This is inversion. Reciprocity is involved when the subject adjusts her position or reach, to hit the nail with the most direct force possible.

"Reversibility" is the structural counterpart to compensations. It, too, has the two forms of inversion and reciprocity. Logico-mathematical structures are completely reversible because they are structures not only of inversion and reciprocity, but of the reciprocal intercoordination of them. For example, the arithmetic operations, by the coordination of inversion and reciprocity, allow us to define a variable in an algebraic statement:

$3x + 2 = 7$
$(3x + 2) - 2 = 7 - 2$ (-2 is the reciprocal of 2)
$(3x)(1/3) = (5)(1/3)$ (1/3 is the inverse of 3)
$\therefore x = 5/3$

Thus, structural reversibility refers to the internal connections of a structure which allow elements in it to be "transformed" into other elements and back to their original state.

b) <u>Mechanisms of Regulation</u>

At this point, one might well wonder what difference there really is between compensations, regulations and functions. The answer is that they are in a hierarchical relationship. (see Chart 1). Compensatory mechanisms are constructed from regulatory mechanisms, which are constructed from functioning. In each case, the prior mechanism contains the property of the next higher mechanism in an incomplete form. That is, functioning has the secondary effect of regulating structure, and regulatory mechanisms have the secondary effect of structural compensation..

This hierarchical relationship explains, though it does not excuse, the variety of names by which Piaget calls these mechanisms, e.g., compensatory regulations for compensations, and regulatory functions for regulations. Regulations are a refinement of functions; compensations are a refinement of regulations. In each case, the life-drive to preserve organization leads to the construction of increasingly specific mechanisms of structural conservation.

Functioning alone accounts for a certain amount of construction (i.e., accommodations.). It is not difficult to see that conservation requires construction, and that the presence of regulations and compensations adds still greater potential for construction. Chart 2 represents the construction of structures by functioning, regulation and compensation. At each step, of course, there can be a return to the original schema(s). Not all functions lead to regulations, nor all regulations to compensations. Whether they do or not depends in the greatest part on the nature of the disturbance which leads to the functioning.

This brings us to a crucial question: Is equilibration different from the regulations inherent in biological functioning, or is it simply an extension of, e.g., compensations. The answer is both yes and no. Equilibration <u>is</u> a "regulator of regulations", and develops from biological functioning itself. Thus it is both a conceptual and actual extension of organic regulations. However, it is also qualitatively different from other organic regulations.

CHART I

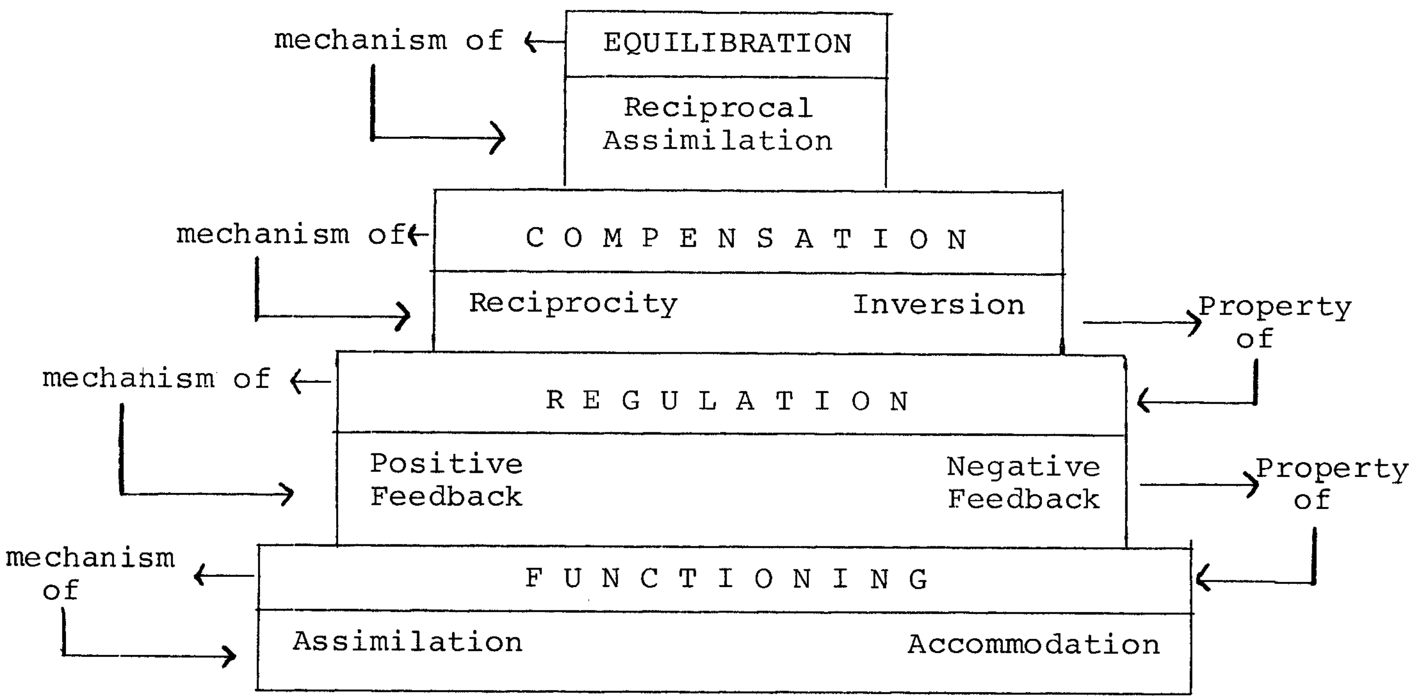
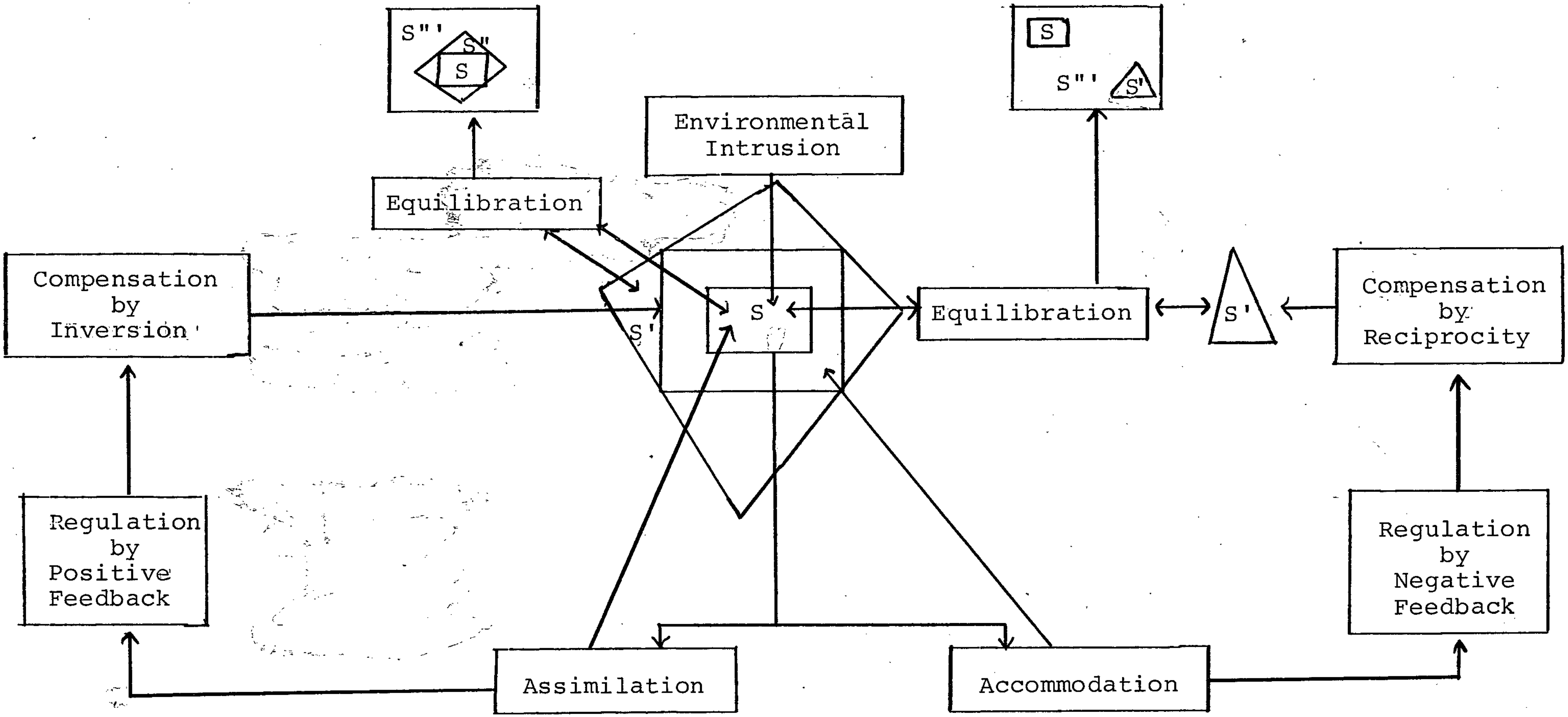

mechanism of
EQUILIBRATION
Reciprocal Assimilation
mechanism of
C O M P E N S A T I O N
Reciprocity
Inversion
Property of
mechanism of
R E G U L A T I O N
Positive Feedback
Negative Feedback
Property of
mechanism of
F U N C T I O N I N G
Assimilation
Accommodation

CHART II

STRUCTURAL CONSTRUCTION THROUGH FUNCTIONING



*See Page 42

The difference between equilibration and other regulators lies in the disturbances which it regulates. Biologically functioning operates on the physical environment of the organism. Biological regulatory mechanisms regulate structures in their relationship to this environment. Cognitive structures are subject to internal disturbances. The accommodation of a cognitive structure, unlike the accommodation of a biological structure, creates not only the structure of accommodation, but a second, complementary structure.

In the case of an accommodation leading to a compensation, the immediate organic requirement is that the accommodation, S', be assimilated to the original structure, S. The assimilation of S' as a subclass of S implicitly entails construction of a subclass of the same order, S" = SnonS. The first form of equilibration or resolution of internal disturbances, thus creates the need for the second and third types, since it creates a second substructure of the same order as S'. Equilibration of the second form creates a new structure, S"' = S' S". And reciprocal assimilation between S, S', S", S"', etc., not only establishes all connections between S and its substructures, but the boundaries of S.

As an example, we can look at the accommodation of a particular classificatory structure. Imagine that a child knows that dogs and cats are animals. She sees a fish for the first time, and identifies it as an animal, because it moves and has eyes. The original structure(s) is "things which move and have eyes, and live on the land". The structure created by the accommodation(s) is "things which move and have eyes and live in the water". The complementary structure created by the assimilation of S' to S is "things which move and have eyes and don't live in the water". (S"). The reciprocal assimilation of these two substructures creates a structure of their intersection, "things which move and have eyes". (S"'). These constructions lead to equilibration of the third form, between the new structure and the two substructures. In this case, that equilibration establishes the class/subclass relationships between S"', and S' and S".

Referring back to Chart 2, it can be seen that conservation by functioning is inadequate to resolve internal disturbances. Indeed, it is only the beginning of them, as it creates the new structures which require equilibration of all three forms. Structural conservation implies construction, but does not determine its form. Compensation determines the form of construction, but does not determine how the new constructions will be integrated into the original structure.

VIII. ACCOUNTING FOR COGNITIVE DEVELOPMENT WITH THE CONCEPT OF EQUILIBRATION

By contrasting cognitive structures and biological structures, and cognitive regulations and biological regulations, Piaget establishes that equilibration is a distinct form of self-regulation. These arguments tell us what equilibration means, and how equilibration is necessary for the internal consistency of Piaget's theory. However, it is still not clear whether the concept of equilibration increases the ability of Piaget's theory to explain cognitive development. If equilibration does not add to the theory's explanation, its usefulness is questionable.

Equilibration is meant to explain certain things which have been observed about cognitive development: that it proceeds through a series of stages, and that the structures of each stage are increasingly reversible, and therefore complete. Based on Chapters One and Two, we can see why equilibration explains cognitive development, and to a certain extent, how it does so. However, in order to fully understand how equilibration explains cognitive development, it will be necessary to look at the kind of explanation yielded by structuralist methods. We will also try to make sense of the varying language that Piaget uses when he talks about equilibration.

a) Construction of Logico-mathematical Structures

The primary reason why equilibration accounts for the development of logico-mathematical structures is that all regulations entail the construction of structures, and the characteristics of the structures so constructed are determined by the characteristics of the regulatory mechanism. The special characteristic of equilibration as a regulatory mechanism is that it regulates by reciprocal assimilation. This differs, e.g., from regulatory mechanisms, which regulate construction by positive or negative feed-back. Each assimilation of an accommodation creates disturbances based on the internal relations of the structure, rather than its relations to the environment. This much said, however, we can still ask just how Piaget purports to account for the pattern and outcome of cognitive development with the concept of equilibration.

To begin with, Piaget's explanation of cognitive development does not proceed by way of simple causal laws. Such accounts, he asserts, cannot deal adequately with the dynamic processes at play in cognitive development. Rather, he formulates an account of cognitive development on the basis of probabilistic laws. Equilibration mechanism, therefore:

> ...do not yield simple causal (laws), but statistical (laws), which should be interpreted in an 'impersonal', or neutral, manner, for example, in the way that we call on the principles of 'least action' in analytic mechanics, to 'describe' the path of an atom as being that which corresponds to the 'least action' in the passage from the point of departure to the end-point (of the motion).[38]

Thus, we would not say "equilibration causes the construction of logico-mathematical structures", but that "the construction of logico-mathematical structures corresponds to a process of construction governed by equilibration mechanisms".

By providing an explanation of development on the basis of increasing probabilities, "...equilibration...accounts for the 'selection' of the actual system from among the range of possibles...".[39] Organic regulations contain the possibilities for initial cognitive regulations. The probability for particular coordinations is increased through functioning, particularly by assimilation of successful (i.e., need-fulfilling) accommodations. Each coordination, or reequilibration, determines a new set of probabilities.

In his earlier work on equilibration,[40] Piaget presents a probabilistic model based on four dimensions of equilibration: field of application, mobility, permanence, and stability. The first cognitive coordinations, arising from biological functioning, is the equilibration of schemata across their field of application (the objects to which they refer). This coordination then provides the possibility for a mobile equilibration, (one which crosses fields) and so on. Internal disturbances arise and are resolved in dialectical fashion, e.g. centration on length, centration on width, with the coordination of these eventually leading to the conservation of volume. In this account, equilibration is simply the name of the dialectical process.

In his more recent works, Piaget has attempted to explain dialectical processes in development, rather than to explain development by them. In <u>The Development of Thought</u>,[41] Piaget presents a model of cognitive development based on the co-ordination of functional negations (negative feedback) and functional affirmations (positive feedback), into structures which are completely reversible. Equilibration, or the process of assimilating accommodations, is the mechanism by which negations and affirmations of particular structures are synthesized, creating structures comprised of reciprocal relations.

In this account, as in his earlier accounts, each equilibration raises the possibility for new disturbances. Unlike a statement of dialectical processes, however, postulating the existence of a mechanism of reciprocal assimilation accounts for the form which the equilibration takes:

> Construction, in being constantly regulated by equilibration requirements, (a self-regulation whose conditions become the more stringent as it steers toward an equilibrium that is mobile and stable at the same time), finally yields a necessity that is a non-temporal, because reversible, law.[42]

A mechanism of reciprocal assimilation, then, accounts for the construction of structures with the special characteristics of logico-mathematical structures.

To further elucidate its explanatory nature, equilibration principles can be likened to the uncertainty principle in modern physics. The uncertainty principle is a "law" which governs what can be known about the speed and position of a sub-atomic particle at any one time. It is a law in the sense that it describes a necessary feature of a certain type of observation. Similarly, equilibration describes necessary features of cognitive development.

b) Language of Equilibration

Also like the uncertainty principle, equilibration "laws" are implicit in that which they explain. This accounts in part for the difficulties people often encounter when trying to make sense of Piaget's theory. To a certain extent, Piaget is simply careless in language use. His terminology often shifts as he uses a number of similar terms to convey roughly the same concept. This can compound the problem of understanding an already difficult theory.

A prime example of Piaget's confusing language is his assignment of various attributes to equilibration, and interchangeable use of the terms so constructed. He speaks, at various times, of "(the) equilibration mechanism(s)", "equilibration process", and "equilibration laws". Although it may be needlessly confusing to the reader, there is no inconsistency or contradiction involved in this particular practice. Equilibration can be rightly called a mechanism, process or law.

One meaning of "mechanism" is the "agency or means by which an effect is produced".[43] Piaget certainly intends for equilibration to be such a phenomenon:

> Equilibration would thus explain the process of transition from prelogical to the local mathematical structures, and, hence, the formation and above all completion of these structures.[44]

The process of progressive equilibrations is the mechanism by which such effects are produced. The regulations required by the character of equilibration mechanisms are laws governing the construction of structures. As for singular and plural forms, equilibration is a mechanism which can be acting on any number of structures simultaneously.

IX. FRUITFULNESS OF THE CONCEPT OF EQUILIBRATION

Now that we know what Piaget means by "equilibration", how it differs from similar concepts, and what Piaget intends for it to explain, we can ask what it contributes to Piaget's theory of cognitive development. Or, in other words, we want to ask "Is equilibration a fruitful concept in the theory?"

As a special mechanism of internal regulation, which regulates cognitive functioning, equilibration is unlike other mechanisms of regulation in Piaget's organic model. Since it regulates functioning by reciprocal assimilation of accommodations into the original structure, equilibration constructs structures whose laws of composition are reversible connections between the elements of the structure. These "reversible" structures are stable to an extent unique among organic structures, because their functioning does not modify their compositional laws.

If we accept Piaget's model of organic functioning as an apt framework for examining cognition, some special mechanism of self-regulation is conceptually required to account for the differences between cognitive and biological structures. On these grounds, the concept of equilibration is useful; equilibration holds the model together.

Piaget, however, intends for equilibration to contribute more to his account than simply internal coherence of the model. Postulating a special mechanism of internal regulation, he maintains, allows us to provide a probabilistic explanation of cognitive development, proceeding through an invariant series of stages, and culminating in logico-mathematical structures. In regard to this claim, it is fair to ask whether his account could be made without recourse to a particular mechanism of the sort that he describes.

This question can lead to questions about the plausibility and/or usefulness of Piaget's account in general. Equilibration is a particularly abstract concept, implied through a complex theory whose basic elements, structures, are themselves abstract. Thus, on reading Piaget, one is often left wondering whether he has explained anything beyond his model itself. It is not the purpose of this paper to provide justification of Piaget's model. We will, however, look at a few points concerning the theory in general, as these points are relevant to the question of the fruitfulness of the concept of equilibration.

a) <u>Equilibration and Piaget's Organic Model</u>

To begin with, we want to ask whether the relationship between equilibration and the reversibility of logico-mathematical structures is merely tautological. That is, do these structures simply "look like" they are regulated by equilibration, or is there reason to say that equilibration mechanisms contribute to the formation of them? Piaget replies, "...observation and experiment show as clearly as possible that logical structures are constructed...".[45]

Piaget's insistence on this point can best be understood in a historical context. To most people today, there is nothing surprising or radical in the idea that cognitive structures are somehow constructed. In fact, the widespread acceptance of this idea is due in large measure to Piaget's work. When he began his studies of children's conceptions of the world, the two prevailing epistemological stands were innateism and empiricist associationism, both of which survive to this day in some form.

These two stands offer opposing and simple explanations for the fundamental concepts of cognition. These concepts, such as non-contradiction, are either given *a priori*, or they are impressed upon the mind as necessary features of the observable world. Piaget counters both these views, saying:

> ...the knowledge of the environment which is so admirably attained by the human mind is only so attained by virtue of an extension of the organization's structures into the universe as a whole.[46]

If anything, Piaget leans toward a form of innateism; he is generally considered a Kantian. However, as he takes pains to point out, the structures of cognition may be latent in biological organization, but this in no way accounts for the process of their construction.

But, we can still ask, does the concept of equilibration add to Piaget's account of the construction of cognitive structures, or could this account be made without equilibration? Insofar as we take his account to be a description of the series of stages of development, the answer is that the particular mechanism he describes is not necessary. Indeed, his many studies of cognitive development *per se* refer to equilibration as an important process, but do not specify its nature in detail.

So, in the strict sense of "prediction", the concept of equilibration is not necessary for prediction to Piaget's theory. Functioning, at this state of cognitive development, makes a reorganization of structures into a new stage increasingly likely. Equilibration is not necessary to predict that each stage will be obtained. Likewise, Piaget has not as yet provided a framework for predicting the particular likelihood of an individual's attaining a higher stage.

There is, however, more to Piaget's theory than the prediction of stages. Besides determining that cognitive structures are constructed in a particular sequence, Piaget is attempting to determine how this construction takes place. In this regard, equilibration is a fruitful concept. It allows the theory to retrodict, or explain the way in which structures are constructed. Although the fact of attaining one level of organization (stage) provides the possibility for attainment of the next, it does not tell us how the organization is attained:

> If the novelty to be construed is suggested by the preceding completions, is it not predetermined? The reply is that the world of possibilities is never complete, nor, consequently, given in advance.[47]

Equilibration, by its particular character of regulation, can explain why cognitive structures are constructed as they are.

Thus, by enabling Piaget's theory to retrodict the course and outcome of cognitive development, equilibration is a fruitful concept in the theory. It should be noted, too, that retrodiction is not a closed book. Experimental studies of equilibration, such as those mentioned in Chapter Five, may yield particular predictive hypotheses.

b) Verificability of Equilibration

In conclusion, there is one further point to be considered. If we are asked to accept that the hypothesis that equilibration mechanisms help form cognitive structures may be more than a retrodictive hypothesis, it is appropriate to ask whether this hypothesis can be verified or falsified. Most likely, the equilibration hypothesis cannot be proven to be false, but only opposed.[48] If one remains within structuralist methods, the particulars of its actions might be modified, as they were by Piaget himself. But even these modifications were the result of inadequacies, not inconsistencies *per se*. The concept and the framework in which it is imbedded are both highly flexible; a good many anamolous observations could be incorporated into the theory without radically changing it.

One could simply deny the entire model, which, in fact, many people do. Piaget apparently enjoys responding to such challenges. Besides his frequent arguments against simple forms of associationism and innateism, he speaks at various times to behaviourists,[49] needs-reductionists,[50] and social-learning theorists.[51] These statements are all variations on the same theme: He is able to account for observations made from these perspectives, while they are inadequate to account for all of his observations, and often, he claims, for their own.

Approaching equilibration both from within the model generated by structuralism, and from without it, we come up against the same question: Is there a better account? With the concept of equilibration, Piaget has brought psychology into the modern scientific world where falsifiability becomes very hazy. The primary, and perhaps only, grounds left for rejecting a plausible theory is the existence of an alternative theory which is able to account for more evidence than the previous one. The only obvious way for this to occur is to come up with a formalization of cognitive processes based on a concept which subsumes equilibration. In this regard, equilibration stands out with other modern scientific concepts as including the possibility for such a construction within itself, and therefore excluding it at the level of formalization

FOOTNOTES

1. Jean Piaget, *The Child and Reality*, (New York: Viking Press, 1973), p. 146.

2. Jean Piaget, *Structuralism*, (New York: Harper & Row, 1973), p. 59.

3. *Ibid.*, p. 90.

4. Jean Piaget, *Biology and Knowledge*, (Chicago: University of Chicago Press, 1971), p. 12.

5. Hans G. Furth, *Piaget and Knowledge*, (New Jersey: Prentice Hall, 1965), p. 1870.

6. Theodore Mischel, "Piaget: Cognitive Conflict and Motivation", in *Cognitive Development and Epistemology*, ed. by T. Mischel, (New York: Academic Press, 1971), p. 332.

7. Jean Piaget, *Six Psychological Studies*, (New York: Random House, 1967), p. 6.

8. John Flavell, "Comments on Beilin's 'The Development of Physical Concepts'," *op. cit.*, T. Mischel, p. 126.

9. *Op. cit.*, Piaget, (1971), p. 17.

10. *Ibid.*, p. 32.

11. Jean Piaget, *Psychology and Epistemology*, (New York: Viking Press, 1971), p. 67.

12. *Op. cit.*, Piaget, (1973), p. 6.

13. *Ibid.*, p. 24.

14. *Ibid.*, p. 10.

15. *Ibid.*, p. 14.

16. *Op. cit.*, Piaget, (1971), p. 141.

17. Jean Piaget, *The Psychology of the Child*, (New York: Basic Books, 1967), p. 11.

18. *Op. cit.*, Piaget, (1971), p. 148.

19. _Op. cit._, (1970), p. 114.

20. Jean Piaget, _The Origins of Intelligence in Children_, (New York: International University Press, 1952).

21. _Ibid_., p. 148.

22. _Op. cit._, Piaget, (1971), p. 366.

23. Jean Piaget, _The Development of Thought_, (New York: The Viking Press, 1977), p. 39.

24. _Op. cit._, Piaget, (1971), p. 30.

25. _Ibid_., p. 26.

26. Cf. _Structuralism_, and _Biology and Knowledge_, pp. 54-60.

27. _Op. cit._, Piaget, (1971), p. 356.

28. _Op. cit._, Piaget, (1967), p. 96.

29. _Op. cit._, Piaget, (1970), p. 15.

30. Jean Piaget, _Logique et Equilibre_, (Paris: Universitaires France, 1957), p. 43. Translated by present author.

31. Cf. Inhelder and others, _Etudes L'epistemologie Genetique_.

32. _Op. cit._, Piaget, (1977), p. 4.

33. _Op. cit._, Piaget, (1970), p. 67.

34. "Equilibrated" is the achievement-word corresponding to the task-word, "equilibration". "Equilibration" itself is sometimes used as an achievement word.

35. _Op. cit._, Piaget, (1977), p. 7.

36. _Ibid_., p. 19.

37. _Ibid._, p. 26.

38. _Op. cit._, Piaget, (1957), Translated by present author.

39. _Op. cit._, Piaget, (1970), p. 113.

40. _Op. cit._, Piaget, (1957), pp. 38-40.

41. *Op. cit.*, Piaget, (1977).

42. *Op. cit.*, Piaget, (1970), p. 67

43. Random House College Dictionary, (New York: Random House Press, 1972), p. 829, #2.

44. *Op. cit.*, Piaget, (1967), p. 105.

45. *Op. cit.*, Piaget, (1970), p. 62.

46. *Op. cit.*, Piaget, (1971), p. 338.

47. *Op. cit.*, Piaget, (1977), p. 182.

48. Cf. Thomas Kuhn, *The Structure of Scientific Revolutions*, (Chicago: The University of Chicago Press, 1962).

49. Jean Piaget, Introduction to Furth, *op. cit.*

50. *Op. cit.*, Piaget, (1971), pp. 45-49.

51. *Op. cit.*, Piaget, (1971), p. 368.

BIBLIOGRAPHY

Flavell, John H. "Comments on Beilin's 'The Development of Physical Concepts'", (pp. 121-128) in Cognitive Development and Epistemology. ed. T. Mischel, New York: Academic Press, 1971.

Flavell, John H. The Developmental Psychology of Jean Piaget. New Jersey: Van Nostrand, 1963.

Furth, Hans G. Piaget and Knowledge; Theoretical Foundations. New Jersey: Prentice-Hall, 1965.

Kuhn, Thomas. The Structure of Scientific Revolutions. Chicago: The University of Chicago Press, 1962.

Martin, Jane R. Explaining, Understanding and Teaching. New York: McGraw Hill, 1970.

Mischel, Theordore. "Piaget: Cognitive Conflict and the Motivation of Thought", (pp. 311-356), in Cognitive Development and Epistemology, ed. T. Mischel, New York: Academic Press, 1971.

Piaget, Jean. Biology and Knowledge. Chicago: University of Chicago Press, 1971.

Piaget, Jean. The Child and Reality: Problems of Genetic Psychology. New York: Viking Press, 1973.

Piaget, Jean. The Construction of Reality in the Child. New York: Basic Books, 1954.

Piaget, Jean. L'equilibration des Structures Cognitives: Probleme Central du Developpement. Paris: Presses Universitaires de France, 1975, trans. as The Development of Thought.

Piaget, Jean. "Logique et Equilibre Dans Les Comportements du Suject", in Logique et Equilibre: Etudes L'epistemologie Genetique. Vol. 1. Paris: Presses Universite France, 1957.

Piaget, Jean. The Origins of Intelligence in Children. New York: International University Press, 1952.

Piaget, Jean. Psychology and Epistemology: Towards a Theory of Knowledge. New York: Viking Press, 1971.

Piaget, Jean. Six Psychological Studies. New York: Random House, 1967.

Piaget, Jean. Structuralism. New York: Harper and Row, 1970.

Piaget, Jean and Barbel Inhelder. The Psychology of the Child. New York: Basic Books, 1969.