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A Point of View on Ontogeny¹

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Abstract. A contradiction arises from the transposition by *Piaget* of the phylogenetic problem of the appearance of new forms to the ontogeny of knowledge. Whereas *Piaget* explained the appearance of new, specific forms in phylogeny by interactions with specific characteristics of the environment, he showed that in ontogeny, new formally equivalent structures are constructed through interactions with a nonspecific environment. The author goes on to show how development can be considered as the organization of contents by preformed internal structures, describes early development as a succession of representational organizations, and discusses the concepts of structure and representation in their relationship with contents. The epistemological question of the interactions between the organism and the environment is considered from a systemic point of view.

The first point I would like to cover is why *Piaget* formulated the problem of the ontogeny of knowledge in terms of the construction of new structures. Historically, *Piaget's* basic concern was phylogeny: What is the explanation for the advent of new forms or structures in the living world? This preoccupation was shared, moreover, by biologists at the end of the last century. *Piaget*, in his work on limnaeas, investigated the influence of different environments on the form of these snails. His

aim was to show that some of their morphological characteristics result from a complex interaction between the genotype and the phenotype. The forms or morphological structures of these snails were considered as new, original forms. *Piaget* tried to solve the same problem in his research on sedums: How do new forms appear, how is the hereditary part of the plant (and, more generally, of an organism) affected by phenotypic variations produced by such and such a characteristic of the environment? In this context, *Piaget* the biologist really tried to consider the

¹ Translated from the French by *Angela Wells*.

specific characteristics of the environment: the environment affects the evolution of the species and plays a specific role in the appearance of new forms. In his theory on ontogeny, however, the environment no longer acts in a specific way. It was only when *Piaget* transposed the phylogenetic problem of the appearance of new forms to the field of the ontogeny of knowledge that he began to consider cognitive development as the successive appearance of new forms or structures [*Piaget*, 1936, 1937, 1947, 1957, 1967, 1975].

For *Piaget*, these new structures – which he calls functional as opposed to material – are determined by the *interaction between the prior structures* of the subject's behavior and the *properties of the environment*. However, several important changes take place in the passage from phylogeny to ontogeny. *Piaget* considered the initial structures of behavior of the child at birth to be formally equivalent for all subjects. As far as the environment is concerned, *Piaget* only took into account the physical aspects of reality which he considered to be equivalent for everyone. Consequently – still according to *Piaget* – the interaction between structures which are equivalent for all subjects and a constant environment necessarily gives rise to new structures which are also equivalent. This is what *Gould* [this volume] defined as the theory of 'common constraints'. Thus, according to *Piaget*, whereas on the biological level the interactions explained the appearance of new *specific* forms due to the *characteristics* of the environment, on the psychological level the interaction explains (still according to *Piaget*) the emergence of forms or structures, which are new compared to the preceding ones, but nonspecific because they all come from interactions with the same environment. It is in

this sense that the action of the environment becomes paradoxically *nonspecific* in the psychological development of the child's behavior. The only variations which are likely to occur concern the speed of development, but never its form. Now, it can be easily established that each individual has his or her own way of acting and reasoning, and this is as true for physical reality as for social reality. Moreover, if one takes into account both the specific and the general aspects of the environment on the one hand, and (to the same extent) the social and physical aspects of the environment on the other hand, then it is possible to imagine that the particular characteristics of our reasoning are as much due to hereditary factors as to environmental factors. If we wish to account for these differences in the way we act and reason, then we must think of the child as constructing something other than formal structures common to all individuals. We consider *Piaget's* structures formal in the sense that they are to varying degrees independent of the contents to which they are applied (and of the contexts in which they are used).

To conclude then, although *Piaget's* aim was to attain structures – the formal instruments of action and reasoning – and disregard content, he nevertheless studied the elaboration of certain contents, but these were the least specific as possible or common to a large number of objects. He studied how certain properties of the object, isolated by the experimenter, are mastered by the child, but he did not take into account the processes which led to their isolation, their extraction, or their identification. It is not, therefore, possible to speak of the development of structures; the question is how are more or less general or more or less specific contents structured or organized by internal structures

which I consider to be preformed. I shall call these organizations representations [Mounoud, 1979, 1981, 1982; Mounoud and Hauert, 1982a, b; Mounoud and Vinter, 1981].

Cognitive Development as a Construction of Representations

The exchanges between the subject and his or her surroundings are organized in a very complex way at all stages of development and, in particular, at birth. It is obvious that birth cannot be considered as an absolute beginning. At birth, the exchanges of the baby with his or her surroundings are defined by a reflex organization which I shall call internal sensorimotor organization. This organization has its own system of representations which I call 'sensory representations'. This sensorimotor organization ensures the realization of a series of movements (sucking, movements of the arms, hands, eyes, etc.) while taking into account an impressive amount of data. In other words, this sensorimotor organization specifies movements related to the information supplied by the sensory receptors. It is not therefore a question of an abstract formal structure removed from all content or indeterminate with regard to content, but of an organization (a model) where the processed objects (the information received) are specifically defined. However, if there is development, if there is construction (and I do not doubt that there is), it is in the sense that the information defined by the sensorimotor organization is going to be redefined by new internal coding capacities that I shall call perceptual. These then are new potentials or capacities of the organism which appear by maturation. They lead to the

construction of a new internal organization which I shall call perceptual-motor. These perceptual representations correspond partly to what other psychologists call the elaboration of memory traces, configurations of perceptual indices, gestalts, schemas, scripts, plans, frames of reference, or systems of meaning.

From this point of view, the behavior of the newborn baby can be considered as simultaneously wholly determined by the internal sensorimotor organization and partly determined with regard to the new abilities or internal perceptual-motor organizations under construction. As these perceptual representations are elaborated, they gradually supplant and integrate the more general sensory representations. Thus, the exchanges between the subject and his or her surroundings are reorganized. The extent to which this reorganization is satisfactory and complete depends on the characteristics of the situations and persons encountered and, of course, on the integrity of the initial organization. Thus it can be seen that here the environment plays a specific and determining role.

We would like to mention briefly in passing that development consists of a succession of internal reorganizations. For example, new coding capacities appear around the age of 18 months: they are what I call conceptual coding capacities. The appearance of these new coding abilities makes it necessary to reorganize the contents again, to construct new representations. This new internal organization is called conceptual-motor. It is constructed in the same way as the perceptual-motor organization during the preceding period.

These internal organizations or reorganizations (sensorimotor, perceptual-motor, or

conceptual-motor) can be more or less structured depending on the nature of the aspects of reality that one comes across and the type of experience one has, but these internal organizations or representations will never be formal structures removed from all organized content and even less so, formal structures that are new compared to those that the organism possesses hereditarily. These internal organizations of contents correspond to what one often calls the subject's knowledge.

I would suggest that we define the notion of the internal organization of contents (or representation) as covering analytical (sampling) and organizational activities bearing upon reality and its variations, upon the properties of objects and their variations, upon the characteristics of a person and their variations, etc. These analytical and organizing activities related to different contents are carried out by preformed structures and coding capacities, as well as by previous organizations.

A Systemic Point of View

To finish, I would like to place the problem of the preformation of structures and the construction of representations within the current epistemological debate which looks at the interactions between the organism and the environment from a systemic point of view. This debate is centered around the problem of the order which the organism creates in the system during its history: Is it a stable order in the sense of a dynamic stability (as maintains *Maturana* in particular [*Maturana*, 1984; *Maturana and Varela*, 1980]) or is there, on the contrary, an increase in the order of the system due to a

hypothetical 'organizational accident', 'instructive interactions', or 'information transfers' (this is the position defended in particular by *Atlan*, 1972)? To put it more simply, should the system be considered as an open or closed system? The answer I would like to suggest is that it must be considered simultaneously as an open system as far as some of its components (representations) are concerned, and as a closed system as far as others (the structures) are concerned.

A system is made up of components or subsystems. Its most important characteristic is that of homeostasis, i.e., it tends to maintain certain relations between its components invariant. One may distinguish three types of components: structural ones (computational capacities), representational ones (memories), and procedural ones (strategies, programs). Moreover, a system has many different states, which achieve differing degrees of homeostasis. In addition, there are couplings between the organism, considered as a system, and the other systems with which it can interact. Now, these couplings with the different structural states of the systems can be more or less optimal, and can lead to different types of relation or exchange.

For example, the possibility for an organism to solicit or display certain invariants in its exchanges with a given environment corresponds to a special coupling between the structural states of this organism and the environment in question. I do not think that, during the psychological development of the human being, there are periods during which the organism and its surroundings function independently (without couplings). On the contrary, I think that an organism is necessarily in a certain coupling relationship with the surroundings with which it interacts. At birth, in particular, there are very complex –

and even optimal – couplings between the baby's organism and the surroundings with which he or she is predisposed to interact, providing of course that the different systems are in full integrity. In other words, reading or cognitive abilities between certain structural states of the system of the organism (certain configurations of nervous activity) and certain configurations of external energies (certain structural states of the environment) are present at birth. These initial couplings, which I consider to be optimal, are disturbed by internal changes of structural states, which are independent of the environment (appearance of new coding capacities). These changes generate a reorganizational process which depends partly, at least, on the specific exchanges between the child and his or her surroundings (construction of new representations and new action programs).

The individual has, then, at his or her disposal different subsystems (called nervous centers by neurophysiologists and psychological or mental functions by psychologists) which allow him or her to organize exchanges with the surroundings. In the case of human beings, the exchanges are strictly determined with regard to certain subsystems and partially determined with regard to others (those in the process of being organized or not yet organized enough). The newborn baby is thus equipped with, on the one hand, a 'reflex' or sensorimotor organization which perfectly determines his or her exchanges with the environment and, on the other hand, what I have called a perceptual-motor organization, which only partially specifies its exchanges. The reflex system allows the newborn baby to make subtle and precise discriminations and categorizations but without distinguishing between the subject and the object; the perceptual-motor system enables him or her to

make only rough discriminations and categorizations.

In a partly comparable way, the adult has simultaneously at his or her disposal different subsystems and organizations, which are used in his or her relations with the environment. These subsystems are specified to varying degrees in relation to certain categories of objects and persons. It is easy to imagine an individual who is capable of subtle distinctions and complex reasoning in one sphere of activity and incapable of fine distinctions and coherent reasoning in another.

However, there is, in my view, an important difference between the child and the adult. The child is obliged to modify the determinants of his or her actions several times during the course of development: when new nervous centers become functional, or when new functions or abilities appear, i.e., mainly because of transformations within the organism. The adult, on the other hand, modifies the determinants of his or her actions mainly because of changes in the environment and the type of experience he or she is undergoing. However, certain internal modifications resulting, for example, from the aging process, can be compared to those due to growth, and can cause necessary and imperative redeterminations. Reciprocally, a certain number of changes in the child can be put down to changes in the environment: changes in attitude and in what one expects from the environment. The redetermination of different types of behavior (new couplings between the organism and the environment) takes place in different ways depending on the characteristics of the situations (more or less specific, more or less general, more or less systematic) and on the extent to which the surroundings favor the development of the adaptive capacities of organisms.

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