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Nooplasis: A Theory About the Formation of Mind

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Abstract

This article is about nooplasis. That is, the article outlines a general model about the dynamic organization and development of mind. This is done in terms of a number of postulates concerned with the architecture of mind, its development and dynamics, and the nature of learning. Specifically, the model postulates that the mind involves systems oriented to the understanding of the environment and of itself, in addition to general processing functions. It is also postulated that the development of each of the systems is partially autonomous and partially constrained by the development of the other systems, and that it involves both system-specific and system-wide mechanisms of development and learning. Finally, it is argued that these postulates suggest a model of constrained constructivism which differs considerably from what is suggested by the Piagetian or the Vygotskian conception of constructivism.

Introduction

This article outlines a theory of cognitive architecture and development. This is done in terms of a number of postulates which summarize our research on cognitive development but also the research of other scholars. These postulates relate to (1) the architecture of the mind, (2) its basic characteristics during development, (3) the dynamics and mechanisms underlying its development, and the (4) the nature of learning. The term *nooplasis* is used to refer to all of these processes. This word is made of two Greek words, the words "nous", which means "mind", and "plasis", which means "construction" or "formation" both as a state and as a process. Thus, this word is able to denote at one and the same time the architecture, the development and dynamics, and the education of mind.

The Architecture of Mind

Postulate 1: The Mind is a Hierarchical, Multisystem, and Multidimensional Universe

According to this theory, the basic architecture of the human mind is biologically given and it remains invariant throughout life. Specifically, the theory assumes that the human mind includes two basic hierarchical levels of knowing. The first of these involves environment-oriented systems, the second involves system-oriented constructs. At the intersection of these two levels there also seems to be a functional system that defines the activation and the interaction between the two knowing levels. It needs to be also noted that each of the levels may itself be hierarchically organized. This architecture will be analyzed below (Demetriou, 1998; Demetriou, Kazi, & Georgiou, submitted a; Demetriou, Efklides, & Platsidou, 1993).

The first of the two knowing levels involves structures addressed to the environment. Thus, the input to this level is information coming from the environment and its output are actions, overt or covert, directed to the environment. Empirical research in our laboratory led to the identification of a handful of such structures: categorical, quantitative, causal, spatial, propositional, and social thought (Demetriou & Efklides, 1985; Demetriou et al, 1993; Demetriou, Efklides, Papadaki, Papantoniou, & Economou, 1993; Demetriou, Kazi, Platsidou, Sirmali, Kiosseoglou, submitted b;Demetriou,Pachaury, Metallidou, & Kazi, 1996; Demetriou, Platsidou, Efklides, Metallidou, & Shayer, 1991; Shayer, Demetriou, Prevez, 1989). Music and drawing, which are now under study in our laboratory, may also be added to the list (Demetriou et al., submitted b).

Each of these domains constitutes very complex *specialized capacity spheres (SCSs),* which are themselves hierarchically organized and which involve many dimensions. That is, each of these systems involves three kinds of components: ready-made kernel elements (which match relations in the environment which are typical of the reality domain to which this SCS is affiliated), operations or computational functions (which refer to systems of action, overt or covert, that the thinker brings to bear on different aspects of the domain to which each SCS is affiliated), and knowledge and beliefs (these are the products of the functioning of the kernel elements and the operations).

The SCSs are domain-specific, computationally-specific, and symbolically biased. Obviously, problem-solving creatures other than humans, such as animals and computers, may possess SCS-like systems which are governed by these three principles. However, possession of SCS-like systems is not sufficient to credit these creatures with mind. To have mind, a cognitive system must be capable of *self-mapping*. That is, the mind is possible only if cognitive experiences, which differ between each other in regard to domain-specificity, computational specificity, and symbolic bias, are felt or cognized by the problem-solver as distinct of each other. Otherwise, they have to be felt or cognized as functionally similar or equivalent.

Thus, creatures capable of self-mapping involve a second-order level of knowing. In our terms, this is the *hypercognitive system*. The input to this system is information coming from the first level (sensations, feelings, and conceptions caused by mental activity). This information is organized into the maps or models of mental functions and the self to be described below. These are used to guide the control of the functioning of the first level. Thus, the hypercognitive system involves self-awareness and self-regulation knowledge and strategies and is conceived as the interface between (a) mind and reality, (b) any of the SCSs or any other cognitive functions, and (c) the processing system to be described below and the SCSs.

This level involves three distinct but interdependent systems: (1) *the person's own model of the mind* (awareness of different cognitive functions such as attention, memory, and inference, and awareness of specialized processes such as those involved in the SCSs); (2) *the person's own model of intelligence* (this model specifies what is and what is not intelligent in a given environment); and (3) *one's own cognitive self-image* (this specifies the person's representations about her own intellectual strengths and weaknesses, preferences, etc.). The person's cognitive self-image is directly connected to dimensions of personality. We have shown, for instance, that the more positive one's self-image is in regard to processing speed, working memory, and reasoning ability, the more open to experience one is (Demetriou & Efklides, 1987, 1989; Demetriou et al, 1993; Demetriou et al., submitted a, submitted b).

At the intersection of the environment-oriented and the self-oriented level there is the processing system. According to the theory, the processing system is a three-dimensional construct. It involves *speed* (the maximum speed at which a given mental act can be efficiently executed), *control* (the maximum efficiency at which a decision can be made about the right mental act to be executed according to the moment's requirements, as indicated, for instance, by response times to stimuli involving conflicting information), and *storage* (the maximum number of information units and mental acts the mind can efficiently activate simultaneously). In a sense, the processing system may be seen as a dynamic field that is always occupied by elements coming from both of the other hierarchical levels, in proportions which vary from moment to moment. Specifically, the input to this system is environment-relevant information, skills, and processes, which pertain to an SCS or something equivalent, and management and evaluation processes, which pertain to the hypercognitive system. Hypercognitive processes are responsible for effecting the orchestration of the SCS-specific processes and the evaluation of the outcome of processing in relation to the goal of processing. We would argue here that working hypercognition is the management system which is responsible for the management of the processing system (Demetriou et al., 1993).

Postulate 2: The Levels and Modules of the Mind Obey Different Formal Rules

However, the architecture of mind as depicted by this theory suggests that no single logical system can suffice to model the different systems of understanding the environment or the self. Alternatively, there is a need for different logics to model the peculiarities of each different system. The first step in this direction would be to show that the various environment-oriented domains of thought, that is the SCSs sketched above, cannot all be modeled by the same logical system. Indeed, we have recently presented a series of logically based proofs which show that each of the five SCSs involves a unique element that is characteristic of the domain, but cannot be analyzed by logic (that is, the specification of essential characteristics, the inclusion of an element to a broader quantitative construct, causal necessity, and the representation of wholeness and the analogue nature of representation, for the qualitative-analytic, the quantitative-relational, the causal-experimental, and the spatial-imaginal SSS, respectively). Moreover, we have also shown that this unique essential element is readily handled by intuition and cannot be reduced to any of the others (Kargopoulos & Demetriou, in press).

A further step in this direction is to show that the computational networks in each of the various SCSs requires different logical systems to be sufficiently modeled. We are now working in this direction.

The Character and Process of Development

Postulate 3: The Mind Develops Along Multiple Roads

In other words, this postulate states that the mind evolves (1) from being perceptually driven and action-bound to self-guidance, reflection and self-awareness, (2) from fewer and reality-referenced to more and reciprocally referenced representations, and (3) from global and less integrated to differentiated but better integrated mental operations.

It is accepted that pre-language infants are able to recognize and abstract meaning from complex patterns of configurations and relations in the environment (Butterworth, 1997). However, pre-language infants are highly attracted by variations in their perceptual environment and they are primarily oriented to doing rather than to thinking and reflection. Moreover they do not seem aware of themselves or of their representational nature until late in infancy.

Preschoolers are able to represent the world and the mind and they can operate on representations. In fact, they possess a theory of mind that enables them to understand and explain others' behavior and even manipulate and deceive them (Chandler, Fritz, & Hala, 1989). However, they are frequently clumsy in doing so, they are easily deceived by appearances (Flavell, Green, Flavell, 1986), and they have difficulties to understand the representational functions of symbols (DeLoache, Uttal, & Pierroutsakos, 1998). They are much more efficient when they have to work with few (one or two) rather than many dimensions or representations (Case, 1992). Moreover they are more at ease under conditions which are overly suggestive of the meaning and the intended solutions, rather than under conditions which require analysis and reorganization to be understood and efficiently dealt with. Thus, they can follow complex conversations by deciphering (that is, inferring) the meaning conveyed in them, but they are not yet able to reason systematically on the basis of logical relations as distinct from the context in which they are embedded (Demetriou, 1998).

During primary school, children become increasingly able to manipulate multiple representations, and they become increasingly resistant to deception from appearances. Thus, they acquire considerable conceptual stability, and their knowledge of the world and the mind becomes fairly differentiated and accurate (for instance they can now differentiate between different mental functions such as attention, memory, and inference). As a result of these advancements, school children begin to reason on the basis of logical relations as such rather than automatically applying inference schemata (Moshman, 1990). However, their general attitude to problem-solving is descriptive (that is, it reflects how things are seen to be) rather than inquisitive, and they think with representations rather than about representations (which reflects an interest in the underlying properties of things and situations and their dynamic relationships as such) (Flavell, 1988).

From adolescence onwards, individuals become able to view representations from the perspective of other representations (Demetriou, 1998). This opens the way for the construction of abstract or synthetic concepts that can represent the most complex and dynamic aspects of reality. Thus, the adolescent's entire approach to the world is gradually differentiated from that of the child. That is, the balance gradually shifts from the description of reality to suppositions about it and to inquiry about suppositions. In other words, there is a shift in the focus of understanding from reality itself to its representation. As a result, knowledge of the mind and of the self becomes increasingly differentiated, accurate, and codified, and the adolescent can now build complex mental maps of the mind in which different mental operations and processes, such as those involved in the various SCSs, are clearly represented (Demetriou et al., 1993, submitted b). Codes of mind raise inferential processes to the level of metareasoning, which enables the individual to think in reference to criteria of logical validity and adequacy (Demetriou, 1998; Moshman, 1990). The endproduct of this shift is a model-construction, a model-testing, and even a model-modeling strategic approach. This gradually generates models of the world which are recognized as such, skills for testing the models, either empirical or conceptual, and even skills for formalizing and communicating the models (Demetriou, 1998).

Later, in the years of maturity, alternative models of reality and action may be simultaneously envisaged and accepted. As a result, relativism prevails and wisdom starts to guide action (Baltes & Smith, 1990).

Postulate 4: As it Occurs at Multiple Levels, Development Has Many Faces

The view of development and mental architecture outlined above suggests that there are different kinds of developmental change. Their nature and form depend upon the system involved and the level of analysis preferred by the researcher.

At a refined level of analysis, such as day- or week-long intervals, the mind change constantly due to variations in the world or simply due its own functioning--which is directed either to the understanding of the world or of itself. Thus, at this refined level, development appears to be a permanent state of the system (Demetriou, 1996).

However, when analyzed globally, development appears to occur in spurts and to result in the acquisition of new forms of understanding-- as opposed to adding skills of the old kind. One example are the changes associated with representational shifts, such as the move from sensorimotor to representational intelligence or from a descriptive to a suppositional attitude towards the world. These shifts frequently seem to demarcate the end of one developmental cycle and the beginning of another.

In conclusion, development seems discontinuous for certain processes at one particular level of analysis and continuous for other processes at another level of analysis. This is an important concept, because both faces of development are equally valid.

Postulate 5: Development at Different Levels or in Different Systems of Mind Requires Different Developmental Mechanisms

The theory claims that different types of change take place through different mechanisms. Specifically, changes in the processing system are concerned with the flow and representation of information in the mind. When these changes occur, processing becomes faster and better able to focus on goal-relevant information and operate on larger blocks of information. Therefore, if changes in the processing system are to be transformed into functional capabilities, mechanisms such as *information search, selective attention,* and *storing and retrieval processes,* which are concerned with information processing per se, are required.

Changes in the SCSs concern the refinement of existing operations, skills and concepts so that they become better tuned to the domain concerned, or can be integrated into larger blocks to deal with more complex aspects of the environment. These changes may be confined either within the same SCS or they may involve more than one SCS. The theory assumes that different mechanisms are required to produce changes within the same SCS from those required to produce changes in the relations between two or more SCSs. For instance, the integration of two units from within the same SCS (such as the integration of hypothesis formation with experimentation into a model construction ability that enables one to systematically build theories about the world) is guided by elements common to both units, such as a general conception of causality. The integration of two units coming from two SCSs (such as integrating quantitative reasoning and spatial reasoning into a graph reading ability) does not have these guidelines. Thus their integration must be constructed ad hoc in relation to the needs of the particular task. Therefore, in each of these occasions of change different mechanisms are required. The terms interweaving and bridging, respectively, were used to refer to these two different mechanisms of SCS change (Demetriou, 1998).

Changes in the hypercognitive system are concerned with self-monitoring, self-mapping, self-awareness, and self-regulation. In other words, these changes are concerned with the running of the mind per se rather than with the context and content in which the running takes place. When they occur, changes in the hypercognitive system may have far-reaching effects in the functioning of all other systems because they may alter the terms of cognitive functioning in general. This is particularly clear in the case of *metarepresentation,* which is the primary mechanism of change in the hypercognitive system. That is, metarepresentation is considered as a process which looks for, codifies, and typifies similarities between mental experiences (past or present) to enhance understanding and problem-solving efficiency. In a sense, metarepresentation is analogical reasoning applied to mental experiences or operations, rather than to representations of environmental stimuli. For example, when a child realizes that the sequencing of the *if ... then* connectives in language is associated with situations in which the event or thing preceded by *if* always comes first and that it produces the event or thing introduced by *then*, this child formulates an inference schema that leads to predictions and interpretations specific to this schema. When abstracted over many different occasions, and somehow symbolized in the mind it becomes a frame which guides reasoning by implication (Demetriou, 1996, 1998).

Postulate 6: Intra- and Inter-Individual Variability is the Rule in Development

Postulate 3 suggests that there are changes which affect all systems and levels of mind at more or less the same age. However, the variability in the levels and systems of mind and in the forms and mechanisms of their development as suggested by the other postulates provides for variations in the development of the various systems involved in the different levels of mind both within and across individuals. For instance, all SCSs do not develop at the same rate in an individual nor is the same mechanism of change applied in the same way across different SCSs. These differences are due to many reasons. One reason is related to the fact that the dynamics of organization differ among SCSs, due to factors such as the status of kernel elements and the internal and unique constraints that define processing within each SCS. Moreover, subjective factors such as familiarity and individual preferences or tendencies will affect how a problem is represented and tackled (Demetriou et al., 1993; submitted b).

Postulate 7: Learning Varies Across Hierarchical Levels or Systems

The assumptions about a hierarchical and multisystem mind which involves structures that deal with different types of problems in the environment bear important implications for learning. Specifically, these assumptions suggest that each of the various hierarchical levels and systems of mind may learn in ways which will make them as efficient as possible in dealing with their own types of problems. Thus, there may be different types of learning, each dependent on the level or system of mind involved. Topographically speaking, learning may be either domain-specific or domain-free. Domain-specific or modular learning springs from particular domains in the environment and it affects the functioning of the corresponding domain-specific modules. This type of learning does not generalize.

Domain-general learning, or hyperlearning, refers to changes in the knowledge structures, processes, and skills which are concerned with knowing and handling the functioning of the mind itself. This kind of learning always involves the hypercognitive system in some way. Logical reasoning is one of the most important products of hyperlearning. By definition, therefore, hyperlearning is transferrable over different domains and, when it occurs, has immediate or delayed implications for the functioning of the other systems (Demetriou & Valanides, in press).

Conclusion: Constrained Constructivism?

Postulate 8: Learning and Development are Constructive but Constructive Possibilities in Any System or Level in the Mind are Constrained by the Condition of Other Systems or Levels

The theory presented here is related to a number of other theories of intelligence and cognitive development, such as the so called neo-Piagetian theories of Case and Pascual-Leone or Gardner's theory of multiple intelligences. These relations are discussed in a number of places (e.g. Demetriou, 1996, 1998; Demetriou et al, 1993, submitted b). Moreover, it is to be noted that research in such diverse fields as evolutionary psychology (Cosmides & Tooby, 1994; Donald, 1991), neuroscience (Thatcher, 1994), and the psychology of individual differences (Gustafsson, 1994) strongly suggests that the picture of mind depicted above is generally accurate. That is, evolutionary theorists argue that evolution has sculpted special purpose circuits which have gradually come under the control of higher order self-mapping skills. This evolutionary sculpture can be seen directly in the architecture of the brain, which involves sets of superimposed structures, some of which are impressively specialized vis-à-vis the environment (such as the visual or the verbal cortex) and others (such as the frontal lobe), which function as general purpose systems for planning and control. Moreover, the conception of development as being both continuous and discontinuous is consistent with modern dynamic systems conceptions of development which suggest that some aspects of mind change smoothly whereas others change abruptly and they lead to major reorganizations in understanding (van Geert, 1994). Finally, it is recognized by many that no single mechanism of change would suffice to explain the development of all systems of mind and also that different systems may involve different types of learning (Siegler, 1996).

What then is the main message of this article? I want to focus attention on the implications that this model has for our conception of the nature of development and learning. A whole mythology surrounds these two basic dimensions of the formation of the mind that we unquestionably take for granted--legacies of Piaget and Vygotsky. According to the myth, these processes are constructive; our postulates above strongly suggest that the myth is only partially true. We have postulated that the mind involves multiple levels and systems which are both distinct and synergistically functioning so that development and learning in any one of them is constrained by the condition of the others. Thus, while development and learning in any system may be constructive to a certain extend, what can be constructed and how this is done are constrained by the condition of many other systems. Thus, it is time to abandon the Piagetian and Vygotskian myth of wild constructivism and consider seriously a model of *constrained constructivism*. In fact, if we are to understand how the mind is formed during development and learning we must pinpoint how development and learning in each of the system constrains and is constrained by development and learning in every other system with which it synergistically interacts and find out how we can remove or ameliorate these constraints, when necessary, and build onto them, when possible.

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