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READING VYGOTSKY at CUNY

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Notes

[1]Other papers presented in the Symposium were: Berger, C., *Everyday and scientific concepts of number from zero to infinity*; Laufer, E., *Acquisition of new concepts among adults*; Phatate, D. D., *Possible underlying neurological mechanisms for Vygotsky's psychological theory*. Discussants were Katherine Nelson and Joseph Glick, Chair, Sylvia Scribner.

[2]The citations to the work in this issue are to Vygotsky, 1934 [ms]; and the page numbers given are those in Minick's draft manuscript. This volume will appear in September, 1987 under the title, *Problems of General Psychology*, by L. S. Vygotsky, translated and with an Introduction by Norris Minick and a Prologue by Jerome Bruner. It also includes six lectures given by Vygotsky in 1932 at the Leningrad Pedagogical Institute. The publisher, Plenum Publishing Corporation, New York, will be bringing out English translations of all volumes in a Russian series, *Collected Works of L. S. Vygotsky*, representing Vygotsky's entire corpus. The English series is edited by R. W. Rieber and Aaron S. Carton.

MIT has issued a revised edition of *Thought and Language* which incorporates text deleted from the 1962 Hanfmann-Vakar edition. Alex Kozulin is translator of the restored text and editor of the new edition.

[3]The reading plan of the Laboratory of Comparative Human Cognition suggested this mode of work.

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How Vygotsky's Notion of "Scientific Concept" May Inform Contemporary Studies of Theory Development

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Within the field of cognitive science, a number of experimenters have explored conceptual development and change within scientific domains, such as, physics, biology, and math. Primarily, the focus has been on the shift between novices and experts in the acquisition of conceptual systems (diSessa, 1983; Chi, Glaser & Rees, 1982; Larkin, 1981). This novice-expert shift involves the restructuring of knowledge as well as an accumulation of new facts. Most recently, in an attempt to describe the development of scientific concepts from early childhood, Carey (1985) has presented a case study of the acquisition of biological knowledge in children aged 4-10.

Drawing on her own case studies and other neonativist work (e.g., Keil, 1979; Gelman & Baillargeon, 1983; Bullock, Gelman & Baillargeon, 1982), Carey suggests that development of domain specific theories is tantamount to the development of formal systems. In our opinion, this body of work suffers two major drawbacks. (1) Scientific concepts are treated as being continuous with early childhood concepts. An emergent, restructuring process is implied but investigators have not proposed specific mechanisms for change. (2) It is not acknowledged that scientific concepts are culturally formulated rather than individually created.

In what follows, we will compare Carey's most recent work with Vygotsky's theory of the development of scientific concepts. We will end with suggestions about how a Vygotskian analysis may enhance the empirical study of scientific concept development and help overcome the drawbacks within current work.

According to Carey, what evolves is an intuitive biology in which superordinate concepts such as "living thing" and "animal" emerge. In addition, core concepts, such as "alive," are reorganized and development is viewed as domain specific. For example, in the shift from novice to expert, theory change would involve the restructuring of concepts and explanatory mechanisms particular to the specific domain of

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knowledge undergoing development. In other words, the development of explanatory frameworks is part of specific theory change and not necessarily part of the development of formal thinking. Particular causal mechanisms belonging to theories undergo change, but there is no change in the foundational notions that underlie all theory building. Therefore, differentiation and integration must be analyzed in the theoretical context from which they are motivated and in which the concepts are embedded.

These scientific theories are systems of relations between objects whose acquisition is influenced by an initial set of ontological categories, such as the concepts "animal" and "living thing." Carey defines these ontological categories as *a priori* categories of knowing. She differentiates these basic categories from "natural kind" concepts, which emerge with knowledge of the world. Examples of natural kinds are Lemon, Dog, and Tiger. Carey's work suggests that a few ontological categories are innate, although not hierarchically arranged in the sense of Keil's theory of innate ontological categories (1979).

> The ontologically basic concepts, being few in number are the background of our conceptual system. And they constrain induction in various ways. (Carey, 1985, p. 163)

These ontological categories are the child's first means of differentiating things in the world, acting as primitive theories about the world. Theory development is therefore characterized as an emergent phenomenon in which a new theory evolves from the old parent theory. This process of theory change is ongoing and can be understood as a paradigm shift similar to that described by Kuhn (1962).

Carey claims that both weak and strong restructuring occur in the acquisition of biological knowledge. Successive conceptual systems are structurally different in the weaker sense if the later one represents different relations among concepts than the earlier one does and if these patterns of relations "motivate" superordinate concepts not found in the earlier system. In the case of the acquisition of biological knowledge, the superordinate concepts of "living thing" and "animal" emerge from the pattern of relations among biological functions in the expert-novice shift.

The essential characteristic of "strong" restructuring is not only that relations change between concepts in the system but that the individual core concepts of the successive systems are changed. This position is influenced by the Kuhnian view, which holds that theory change/history of science proceeds through paradigm shifts in which both relations between concepts as well as the core concepts of some system changes in the shift from old to new theories.

Although her ontological categories may account for primitive theories or domains of knowing, they cannot account for fully formed scientific theories. Moreover, Carey alludes to a mechanism that motivates conceptual change within domains (that is, she suggests that once these ontological categories become explicit they are reorganized), but she does not explain how this occurs. In addition, she does not consider the historical embeddedness of scientific theories, i.e., she does not acknowledge that they are culturally formulated and presented to learners as complete systems. Her work almost suggests that a child can create a scientific theory in the absence of instruction and interaction.

In sum, Carey leaves us with several unanswered questions. Even if we accept her notion of innate ontological categories, such categories cannot account for how children manage to learn theories that are culturally determined. What mechanism is involved in acquisition? How does instruction map onto, interact with, or transform existing ontological categories?

Although Carey and Vygotsky share a definition of scientific concepts as essentially a "system of relations between objects" that develops, Vygotsky sees their development in a strikingly different way. Unlike Carey, Vygotsky sees scientific concepts as distinct from what he calls "everyday concepts." Rather than viewing scientific concepts as emerging from everyday concepts, he sees the development of each as moving in opposite directions, acting upon and transforming each other dialectically.

Importantly, scientific concepts are culturally formulated and transmitted through instruction. In the process of acquisition, they transform and influence thinking. In this sense, mind is socially formed.

> [Spontaneous concepts] create a series of structures necessary for the evolution of a concept's more primitive, elementary

> aspects, which give it body and vitality. Scientific concepts, in turn, supply structures for the upward development of the child's spontaneous concepts toward consciousness and deliberate use. Scientific concepts grow down through spontaneous concepts and spontaneous concepts grow up through scientific concepts. (Vygotsky, 1962, p. 116)

According to Vygotsky, children first acquire knowledge somewhat rotely in the process of the social activity of instruction; with development, scientific and everyday concepts interact dialectically and what gradually emerges is in depth understanding, or what Vygotsky calls "true concepts."

Unlike Carey, Vygotsky addresses not only development within specific domains of knowledge, but the impact of learning scientific concepts on general development. However, although Vygotsky's work addresses the notion of mechanism more clearly, it is underdeveloped with respect to explaining the development of bounded domains of knowledge. In addition, he does not address anything like Carey's *a priori* ontological categories.

However, a central notion in both works is that the "acquisition" of culturally formulated formal systems requires the reorganization of some more primitive system, consisting of "natural kinds" or "spontaneous concepts" within specific domains. The question remains as to how this process might occur. Here, both Carey's and Vygotsky's work suggest some avenues for study. Vygotsky's discussions of instruction, conscious attention, and the role of signs may point up principles that may act in the refining of domain specific knowledge. That is, they may jointly act in a complex way upon ontological categories of knowledge, such as Carey describes, allowing the refinement of knowledge within a specific domain.

Below is a description of how this might occur. As noted throughout this paper, "scientific concepts" or "theories" are essentially systems of relations. These relations are culturally transmitted through instruction and acquired in a somewhat "top down" manner. For example, one may be able to have linguistic command of certain partial relations before he or she actually understands them and can apply them to the real world with something like an in depth understanding; when the individual can apply schooled abstract concepts to the concrete, his or her spontaneous concepts have been transformed by them.

> To be adequately characterized, each concept must be placed within two continua, one that represents objective content and another that represents acts of thought apprehending the content [spontaneous concepts]. (Vygotsky, 1962, p. 113)

What is special about instruction, practice, and the other forms of discourse involved in schooling? We propose here that the very act of making one's current understanding explicit, through speaking, writing, or in discourse makes one's concepts accessible to the kind of processes necessary for reorganization. Through discourse the learner's concepts are gradually reorganized to match the formal system being acquired.

The processes necessary for reorganization include addition, refinement, and decomposition. These operations require an attentional effort on a system of relations that has been made explicit. Unlike spontaneous concepts or ontological knowledge, formal systems cannot be acquired implicitly, but must be made "accessible" for reorganizing operations. The explicating vehicle in both spontaneous and formal systems is some word or sign that embodies a concept. Once a system of signs is explicit, it can be rearranged, re-prioritized, or broken down analytically. These kinds of operations require conscious control and reflection. In a school setting, the role of instructor would therefore not be that of a passive provider of knowledge. Rather, the instructor would be an agent of a kind of regulatory reformulation process. The knowledgeable instructor may (through feedback, gradual challenge, and responses to the student's errors) guide the student in this process.

That is, it may be that individuals initially do organize the world in terms of broad ontological categories of knowledge as suggested by Carey. But these categories developing and refining on their own cannot account for the success children and adults attain at learning a particular culturally formulated and socially shared theory. A kind of "stepped up" Vygotskian analysis is required to understand how people move from thinking in terms of broad heterarchical categories to acquiring and refining formal theories within specific domains. We propose that instructional discourse and other kinds of activities that explicate

systems of relations make such relations amenable to refinement, reorganization, and correction. This kind of process acts as an essential bridge between a primitive understanding and a fixed culturally formulated theory, enabling acquisition and eventually in depth understanding, or "making the concept one's own."

Studies designed to describe this process must therefore study not only the subjects' movement from novice to expert, but also the discourse process that allows this development and its influence at each point. What is needed is an analysis of the discourse/instruction process along with the more traditional analysis of the learner's initial categories and patterns of change over time.

Currently, one of the authors (Di Bello, 1987) has been conducting a series of studies to capture this process in adults learning computer software systems with minimal instruction from interactive computer tutorials designed to compel explication. None of the subjects has prior experience with computers. Results indicate that those who learn the system well (i.e., those who can solve non-routine problems after training) are those who are given the opportunity to explicate their changing notions at several points during training. They are given some "correct" information about the system only after an opportunity for explication. These subjects then use the "correct" information to reorganize their current notions. Descriptive data of the subjects' errors show that their initial concepts as novices structurally resemble Vygotskian spontaneous/everyday concepts even though these same subjects routinely use formal reasoning in other domains (e.g., their areas of professional expertise). Since subjects were all (1) normal adults and (2) unfamiliar with the target domain, this finding lends support to the claim that formal development is domain specific.

Subjects in two other conditions which more closely resemble traditional teaching methods (i.e., clearly presented information with demonstrations or guided practice) did not learn nearly as well. Although they performed as well as the aforementioned subjects on written tests asking questions *about* the system, they could not solve non-routine problems requiring an in depth understanding.

In conclusion, the discourse process seems central to developing an in depth understanding of a formal domain. At present the process of acquiring any formal system is not adequately understood. Currently, both authors (Di Bello, 1987; Orlich, 1987) are developing ways of further elucidating the actual processes involved in discourse and subsequent acquisition of formal systems of knowledge.

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