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Domain Specificity and Variability in Cognitive Development

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There are core-specific and noncore-specific domains of knowledge, but only the core-specific domains benefit from innate skeletal structures. Core skeletal domains are universally shared, even though their particular foci may vary; individuals vary extensively in terms of the noncore domains they acquire.

INTRODUCTION

The Larivée, Normandeau, and Parent review (2000, p. 823) is concerned with the fact that "inter- and intraindividual variations appear to be much more important than Piaget had estimated." The focus is on psychometric patterns of observed individual differences across multiple Piagetian tasks. These patterns served as the basis for the theoretical position that is unveiled as the paper progresses. The line of research by a number of theorists in French-speaking Montreal and Switzerland started out as a readily identifiable neo-Piagetian approach. It eventually became transformed into a pluralistic and multidimensional model of cognitive development and its functioning. Themes of domain-specific mental structures, analogical and propositional modes of information, and multiple developmental pathways to new knowledge structures—pathways that can differ both in their routes and termination points—take the front seat. Piagetian terms like infralogical and logical structure, concrete and formal operations, equilibration and décalage are peppered throughout the text. Nevertheless, I finally realized that the cumulative position has a decidedly anti-Piagetian flavor. At this point in the history of the work covered, the fundamental Piagetian idea that there are universal structures of mind that develop through stages almost disappears.

A theory of cognitive development must account for systematic sources of variability. Although the account that I am developing with my colleagues (see, for example, Gelman & Greeno, 1989; Gelman & Williams, 1998) overlaps in some ways with the one reviewed by Larivée et al. (2000), there are some salient differences. To illustrate this, I have chosen to discuss the shared idea that cognitive development involves the acquisition of domain-specific mental structures. Here I focus on my distinction between *core* and *noncore* domains so as to illustrate how a domain-specific theory can hold that there are universals and have an account of variability. Elsewhere I have discussed systematic sources of variability in cognitive development within the theme of performance versus competence (see Gelman, 1994; Gelman & Greeno, 1989).

WHAT IS A DOMAIN?

I define a domain of knowledge in much the same way that formalists do, by appealing to the notion of a set of interrelated principles. A given set of principles, the rules of their application, and the entities to which they apply together constitute a domain. Different structures are defined by different sets of principles. Therefore, we can say that a body of knowledge constitutes a domain of knowledge if we can show that a set of interrelated principles organizes its rules of operation and entities. Sets of principles carve the psychological world at its joints, thereby producing distinctions that guide and organize our differential reasoning about entities in one domain versus another. In this way, available domain-specific structures encourage attention to inputs that have a privileged status because they have the potential to nurture learning about that domain; they help learners find inputs that are relevant for knowledge acquisition and problem solving within that domain.

I have argued that counting principles and the arithmetic principles that operate on their output of cardinal numerosities constitute a domain (e.g., Gelman & Williams, 1998). Some of the uses of the concept of domain in the Larivée et al. (2000) review of some French-language research is consistent with this definition and some are not. For example, the distinction between items in the physical domain as opposed to the spatial domain could well parallel the distinction between the core domains of intuitive physics and space. However, domain-specific theo-

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rists are not likely to endorse the idea that scripts also constitute a domain. At least thus far, no description of the set of principles uniquely specifies scripts. Furthermore, scripts are analogous to the heuristic prescriptions for solving problems in mathematics, which should not be confused with the mathematical domains themselves (algebra, calculus, theory of functions, and so on).

The reader should not conflate notions of domain-specificity and innateness. Nothing in the offered definition of a domain requires that a domain-specific knowledge structure be built on an innate foundation. Only some of the many domains that people acquire result from the facilitatory effects of innate skeletal structures. Core domains constitute a small universal class of knowledge structures. Noncore domains are members of an extremely large class. We can say that core domains are privileged in the sense that their acquisition can take advantage of existing, implicit structures, no matter how skeletal in form these may be. Given that the mind finds it easier to learn something about structures it already has, no matter how nascent, beginning learners who possess implicit knowledge of at least the skeletal form of a core domain already have the wherewithal to find and assimilate relevant data. That is, inputs whose structure is consistent with the existing mental one are able to feed the epigenesis of the nascent structure and its domain-specific knowledge base.

ON VARIABILITY

Acquisition can proceed with or without the explicit help of others. In this sense, learning can take place "on the fly" as the learner encounters examples of domain-relevant inputs to assimilate to an existing structure. We say that the class of relevant inputs includes those instances whose structure can be mapped to that of an existing mental structure. The more examples of relevant inputs in the environment, the greater the likelihood that individuals will attend to and assimilate the offered inputs. Similarly, the greater the number of examples, the faster should be the rate of acquisition. That is, one source of variability is tied to the extent to which there are many redundant inputs for acquisition. An account that gives the mind some skeletal structures with which to actively engage the environment from the start is committed to the idea that very young children sometimes use very abstract data-processing devices. For example, young children will pair a novel animate object (an echidna) with a praying mantis as opposed to a multispoked wheel (Massey & Gelman, 1988); therefore, they rely on the higher order animate–inanimate distinction and not on surface similarity.

Because skeletal mental structures are attuned to information in the environment at the level of structural universals, not the level of surface characteristics, relevant data are abstract and not bits of sensation or concrete percepts. Still, there is much about which our young know little—if anything. This contributes to the general view that infants and young children are perception bound. For us there is an alternative way to characterize the conditions under which they use perceptual surface cues: They engage perceptual strategy as a default information-processing one when they lack knowledge. This interpretation of the effects of the role of domain-specific knowledge parallels a very interesting aspect of the pluralistic and multidimensional theory of cognitive development that is presented in the Larivée et al. (2000) review. This is the idea that although analogical processing is more dominant than propositional processing early in development, both are available to use. Both positions assume that there are at least some conditions under which young children engage in higher order interpretations of inputs than would be expected if they were really constrained to function at the sensory-perceptual surface level.

Even if all normal humans share those sets of principles that organize core domains, it is unlikely that the particular version and display of those principles will be common across time with individuals and between individuals in either the same or different cultural environments. Children in cultures that have very different count lists can share implicit universal knowledge about the counting principles even if the count terms and generative rules for new terms are different. Similarly, there can and will be variability in the kinds, timetables, and settings that different cultures offer as well as the examples that learners within a given culture attend to and assimilate. Therefore, systematic variations of the availability of relevant examples—within and across cultures—can yield systematic variability in the rate of acquisition, conditions of use, and breadth of knowledge in a domain.

My discussions about knowledge acquisition in core domains have treated structure mapping as a fundamental learning tool. The idea is that given any structure, the mind has the wherewithal to identify inputs that can be structurally mapped to its existing domain. Hence, even a set of skeletal principles can nourish its own development, given that its structures or substructures are consistent with its already-present structure or domain-relevant contents. In noncore domains, however, the learner must acquire both the structure and the domain-relevant content pretty much from scratch. Therefore, no such advantage exists for noncore domains. This a major reason why the mounting of a new conceptual structure is so difficult (Bransford, Brown, & Cocking, 1999). Variability within and between individuals as to whether they mount a new noncore knowledge domain and how long they take to do so is the rule.

Variations in individual interests, information-processing capacities, cultural background, abilities, knowledge levels, access to specialized learning opportunities, and time spent learning about a noncore domain are critical contributors to the kinds and levels of noncore domains that are acquired. Individual differences become even more pronounced when one considers the qualitative differences between *novice* and *expert* knowledge within a domain and the extent to which the domain is a purely formal one (Bransford et al., 1999). Examples of noncore domains help make these points. These include chess, automobile mechanics, sushi making, floral arrangement, x-ray reading, music criticism, Newtonian mechanics, string theory, phonetics, and even cognitive development. Although we expect all normal humans who are living in adequate (i.e., nondeprivation) environmental conditions to acquire knowledge about all core domains, the same cannot be said for noncore domains. Put differently, we should expect that very few among us will be able to rival the likes of a Benjamin Franklin or Leonardo da Vinci.

How should one place my comments about variation alongside the thesis development in the Larivée et al. (2000) paper? The intent is to encourage others to compare and contrast the contributions of the French-speaking research teams covered in the paper to those in the English-speaking communities working on the same goal—an account of the systematic sources of variability that contribute to insights about the nature of conceptual acquisition and conceptual change.

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