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Beyond Modularity: A Developmental Perspective on Cognitive Science by Annette Karmiloff-Smith. Cambridge, MA: The MIT Press. Review by Michael Tomasello and Philippe Rochat. Pp. 234 + xv. \$35.

Not many people could attempt what is attempted in this book: a synthesis of Piagetian and neo-nativist approaches to cognitive development enlightened by a connectionist approach to cognitive science - all of which is underlain by a proposed mechanism of developmental change that makes the whole thing possible. In fact, Annette Karmiloff-Smith is probably the only person who could make such an attempt: in the 1970's she was a close collaborator of Piaget and other major figures of the Genevan school, and more recently she has been developing her own research program and theoretical models. In this long-awaited book, Karmiloff-Smith updates her theory of Representational Redescription (RR) in the context of the latest research findings and theoretical advances in the study of human cognition and cognitive development. The model originates from what she describes as her "epistemological schizophrenia - accepting the need for some innate predispositions . . . while maintaining a constructivist view of subsequent development" (p. 77).

The book is meant for a much wider audience than cognitive-developmental psychologists. In the opening sentence of the volume, Karmiloff-Smith states her intention "to persuade students and scientists in other areas of cognitive science . . . to treat cognitive development as a serious theoretical science contributing to the discussion of *how* the human mind is organized internally, and not as merely a cute empirical database about *when* external behavior can be observed" (p. xiii). In the first chapter entitled "Taking Development Seriously" the author argues forcefully that the developmental perspective within cognitive science is indispensable because it helps to specify an initial architecture of human cognition, basic processing mechanisms, and the nature of developmental changes that lead to adult cognition. In this chapter she also addresses herself to issues of modularity and nativism as they are currently being discussed both by philosophers such as Fodor and by neo-nativist

psychologists such as Spelke. The new findings from this perspective lead Karmiloff-Smith to conclude that Piaget's anti-nativism and across-the-board stages no longer provide a viable developmental framework for the study of cognitive development. She nevertheless remains close to Piaget in her focus on representational changes, retaining the basic idea that cognitive development is an active construction, but abandoning the general structures and mechanisms proposed by Piaget. In their place, she proposes the RR model. The basic assumption of the model is that cognitive development and representational changes in the child rest on the unique ability displayed by humans to take their own representations as objects of cognitive attention.

The heart of the book is an account of cognitive development in five domains, using an approach that views the child as a budding expert in each domain: the child as linguist, physicist, mathematician, psychologist, and notator. Within each domain there are phases (not stages) of development that are common, but they take place at different ages. Each domain thus begins with its own innate architecture, to which are added "representational adjunctions" on the basis of information from the external environment. These do not change the basic nature of the child's existing representations, which at this point are procedural and implicit only; they simply result in "behavioral mastery" of certain micro-domains within each domain. These implicit procedures (I-level representations) are cognitively bracketed as organized totalities and completely domain-specific - their components are not available to other cognitive domains or systems. This soon changes as the process of RR begins. It begins when the child no longer focuses on external data, but rather when "system-internal dynamics take over so that internal representations become the focus of change." (p. 19). What this means specifically is that the I-level representations are taken as objects of cognitive attention and redescribed into a "higher-level language" that is common across the different domains. Translation into this interlingua opens up the component parts of the procedures to potential intra-domain and inter-domain representational links.

There are at least three different levels of this redescription: level E1 redescriptions are explicit and their components are manipulable by other cognitive systems, but they are not

available to consciousness or verbal report; level E2 representations are manipulable and may be consciously accessed, but they are not available to verbal report; and level E3 representations are manipulable and available to both consciousness and verbal report. Each of these levels is "a more condensed or compressed version of the previous level" (p. 23), in the sense that only certain aspects of the lower level are retained in the transformation to the higher level. In this process, stable representations at one point of the child's development are subject to a re-formulation in more abstract terms. Acknowledging that there are several alternative models by which the RR process may take place, Karmiloff-Smith describes it in general terms, as a process of "appropriating stable states to extract the information they contain, which can then be used more flexibly for other purposes." (p.25). At an epistemological level, the RR model postulates that cognitive changes in terms of redescription occur when a stable state is achieved, this stability being viewed as necessary for the RR process to occur. This position is in sharp contrast to views that emphasize conflicts and contradictions as major sources of progress in development (i.e., Piaget's model of equilibration).

This general model is applied to the five different domains, one per chapter in Chapters 2 - 6, with an adaptation needed in each case as each domain has, to some degree, unique properties. In the domain of language, innate constraints are posited in speech, semantics, and syntax, with the RR process leading to the kinds of reorganizations that produce U-shaped developmental changes in linguistic organization (e.g., the *went-goed-went* progression characteristic of many preschoolers) and ultimately to the metalinguistic competencies of the schoolage child. In the domain of the physical world, the new and exciting work by infancy researchers such as Spelke and Mandler is recounted as evidence that young infants come into the world with much innate knowledge about objects - with the metacognitive knowledge of physics characteristic of older children cited as evidence of the operation of RR. In the domain of mathematics, the research on infant subitizing is used as the innate foundation, with different levels of the counting and arithmetical operations of preschoolers used to illustrate the RR model at work. In the domain of social cognition (child as psychologist), infants'

attention to human faces and their protoconversations with adults are taken as the innate starting point, with their theories of mind and understanding of propositional attitudes posited as later redescriptions of this same knowledge. Finally, in positing a domain for written notation (children's skills of drawing, writing, etc.), Karmiloff-Smith draws mostly on her own groundbreaking work on children's spontaneous use of notation systems to elucidate the domain-specific starting point, drawing on more traditional work on children's acquisition of culturally conventional forms of drawing and writing to illustrate subsequent representational changes.

The final three chapters of the book attempt to tie it all together through further discussions of domain specificity and the RR model. In Chapter 7 attention is given to a discussion of Piaget's constructivism in light of atypical child development - i.e., autistic, Down Syndrome, and Williams Syndrome children - with an eye to bolstering the argument for domain specificity as a key characteristic of human cognitive development (*contra* Piaget). Chapter 8 is devoted to exploring connectionism as a useful tool in modelling cognitive development. While she sees much promise in this approach, Karmiloff-Smith ends up concluding that what connectionism is missing is some process of RR which could create and maintain different levels of human cognition - which she believes are clearly evident in each of the domains reviewed. In a brief final chapter, there is some discussion of the cognition of nonhuman animals, culminating in this description of the importance of the RR model:

The RR model is fundamentally a hypothesis about the specifically human capacity to enrich itself from within by exploiting knowledge it has already stored, not by just exploiting the environment. Intra-domain and inter-domain representational relations are the hallmark of a flexible and creative cognitive system. The pervasiveness of representational redescription in human cognition is, I maintain, what makes human cognition specifically human. (p. 192)

There is no question that the proposed model is extremely important, providing a new theoretical paradigm that hopefully will provide an avenue of exchange between cognitive scientists and developmental psychologists. Such exchange is sorely needed as many cognitive scientists view developmental psychology as a mostly descriptive ages-and-stages enterprise,

while many developmental psychologists view cognitive science as a mostly sterile (acontextual, asocial, adevelopmental) boxes-and-arrows enterprise. Although there is clearly still a long way to go, Karmiloff-Smith's book is a good first step.

While thus applauding very strongly Karmiloff-Smith's overall effort, we would also like to make three more critical comments about the book. First, we believe that the argument for the importance of a developmental perspective on human cognition could be made even more strongly than Karmiloff-Smith makes it. As of now, many cognitive scientists - especially those who employ various modelling techniques - analyze their domains of interest into components and processes based on some personal intuitions (and perhaps a few reaction-time experiments). But the structure of human cognition bears the stamp of its history, and so a much more natural and effective way to analyze any given domain is in terms of the fundamental components that have been put together during ontogeny. Thus, for example, the new work by Spelke and colleagues shows just which conceptions of objects provide the infants' initial framework (i.e., solidity and spatio-temporal continuity), and which are added on to those later (e.g., gravity). This type of demonstration is unquestionably crucial to our understanding of the structure of human cognition. It is also true that a key characteristic of human cognitive systems that has proved very difficult to model on machines is flexibility. Flexibility is an outcome of development - as Karmiloff-Smith argues so convincingly - and it may not be attainable in systems that are merely expert in one domain. It may only emerge in systems forced to develop and adapt in complex ways to a complex, multidimensional environment.

Second, in the approach to human ontogeny proposed by Karmiloff-Smith, attention to the cultural dimension of development is minimal, as it is in Piaget. This is a serious omission considering that a large part of human cognitive development consists in children learning from other human beings things that have been devised collaboratively by adults and modified to meet new exigencies over many generations of history. Thus, the child does not need to invent the language that it learns to speak, the tools it learns to use, and one can only speculate what children's development of mathematical and notational skills would be if there were not some

cultural conventions already existing. And these pre-existing cultural tools do not just lie around waiting for the child to pick them up; adults interact with children using all kinds of cultural (including linguistic) conventions, and they actively teach them all kinds of things that they would not be able to figure out for themselves. The nature and extent of these cultural tools and modes of cultural interaction are very likely unique to the human species. Thus, while we are generally sympathetic to an approach stressing the active organism constructing its world, we must not forget that an important part of that world comes to the child prestructured by previously-existing intentional beings.

Finally, we would just like to point out what Karmiloff-Smith already knows. A fundamental problem with the domain-specific approach is how one determines what is to count as a domain. Fodor has one way of doing it, Howard Gardner has a completely different way, some of the neo-nativists have other ways still, and Karmiloff-Smith has her own preferred way. Domain-specificity is a characteristic of human cognition in some sense, but it is not clear precisely how. It is our view, for example, that Karmiloff-Smith's attempt to establish written notation as a separate domain is not fully successful, and there are clearly in our view deeper connections between children's social cognition and language skills than she admits (and probably between objects and mathematics as well). And so, while we do not have answers to offer, we simply wish to caution that before the neo-nativist component of Karmiloff-Smith's model can be fully fleshed out, some theoretical work on what are the basic domains of cognitive development - and how we go about determining them - remains to be done.

We should conclude by saying that this is a very enjoyable book to read, well-written and full of personal anecdotes and stories. Thus, at one point Karmiloff-Smith wonders: "How I wish Piaget were alive today. What, I wonder, would he make of the exciting new findings on infant knowledge about the physical world?" (p. 65). In this musing is captured, we think, the unique mix of nostalgia and excitement that permeates the book, as a leading developmentalist struggles to create a theory that is true both to her theoretical roots and to the new research findings that are challenging those roots.