2006

Mind, Development, and Evolution. (Review of Evolution and Learning: The Baldwin Effect Reconsidered)

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Evolution and Learning: The Baldwin Effect Reconsidered

Edited by Bruce H. Weber and DavidJ. Depew. Cambridge, MA: MIT Press, 2003. 341 pp. Cloth, $50.00.

The Baldwin effect was not called the Baldwin effect until it was almost 60 years old. In 1953, George Gaylord Simpson published an article in the journal Evolution using that phrase as a title, and thus the effect (or, as Simpson declares, the "factor, principle, or hypothesis, as you will," Simpson, 1996, p. 100) acquired a name.1 The original proposal of this effect was made nearly simultaneously by J. Mark Baldwin, C. Lloyd Morgan, and H. F. Osborn in separate articles published in 1896.

And just what, many readers may ask, is the Baldwin effect? Here we get to the problem. "The general thrust of the idea," says Depew in his introductory chapter, "is to urge that, under some conditions, learned behaviors can affect the direction and rate of evolutionary change by natural selection" (p. 3). That is, Baldwin, Morgan, and Osborn sought to provide a non-Lamarckian mechanism for behaviors and other characteristics an organism takes on during its lifetime to become hereditary and to thereby affect evolution.

This collection of essays submits the Baldwin effect to historical and philosophical analysis and then attempts to move beyond the limited phenomena that might be part of the effect to address broader issues about the relationship between evolution and learning.

The three sections of the book are a somewhat mixed bag. In general, the sections do not really cohere around single topics; nevertheless, there is a lot in this book to provoke readers to think seriously about the interaction of development and evolution, about the evolution of the mind, and about a recasting of important aspects of the evolutionary process.

The first section of the book shows unfortunate effects of its growth from a 1999 conference. Readers new to the issues under discussion will feel themselves entering the middle of an interesting, ongoing debate. Having missed the beginning of the debate, they may find it difficult to follow all the strands of the arguments.

A complicating factor is that several questions are being discussed at once, including the following:

> What, beyond the "general thrust" cited earlier, is the Baldwin effect, and is that the same as what Baldwin, Lloyd Morgan, and Osborn said it was?

Does the Baldwin effect have to involve "learning" or active (i.e., conscious) choices of behaviors by individual organisms?

Is the Baldwin effect the same as Waddington's (1953) notion of genetic assimilation?

Does the Baldwin effect actually occur in nature, and if it does, how important is it?

Is the Baldwin effect simply a trivial aspect of natural selection?
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How do the learned or acquired characteristics become genetic adaptations?

Not surprisingly, no answers are reached, although different participants in the debate do have different answers to some of the questions. As Depew points out, the answers to all these questions (including the one about the definition of the effect) may depend on one's theoretical orientation. Therefore it is not surprising that these authors, with such different theoretical orientations, do not agree on much. (What is surprising is that theorists as different as neo-Darwinian philosopher Daniel Dennett and anthropologist Terrence Deacon, who advocates a multilevel and semiotic approach to evolution, manage to agree on anything at all. In fact, Deacon and Dennett are both "Baldwin boosters," although they may not agree on what they mean by "the Baldwin effect.")

Section Two of the book provides a more unified perspective. Three of the four chapters in this section (by Moore, by Oyama, and by Griffiths) recast the Baldwin effect in terms of the developmental systems approach to evolution (Oyama, 1985; Oyama, Griffiths, & Gray, 2001) .

In contrast to the modem synthesis approach to evolution, the developmental systems view takes the ontogenetic process seriously as part of evolution. Where proponents of the modern synthesis reduce evolution to transmittal of genes, developmental systems proponents see evolution acting on entire "repeated assemblies" (cf. Caporael, 2003), recurring complexes of internal (e.g., genes, cells) and external (e.g., environment, conspecifics) factors that in their interrelation lead to the development of actual phenotypes.

With attention focused beyond the limited question of what genes get passed from generation to generation, it becomes less important to develop a specific mechanism whereby changed behaviors taken on by organisms within their lifetime become part of the gene pool. Evolution itself is an interaction between intraorganismic and extraorganismic components. Developmental systems theorists do not believe that evolution occurs only through a gene for a particular trait. From this perspective, all of evolution is Baldwinian.

The fourth chapter in Section Two of this book, written by biologist Brian K. Hall, is a cogent analysis of the Baldwin effect and related phenomena. It would have served well as an introductory chapter to the entire book.

Section Three of Evolution and Leaming addresses contemporary work analyzing the nature of the Baldwin effect. Puentedura reports on attempts to develop computer models of the effect (especially the important model developed by Hinton and Nowlan, 1996). Gilbert contends that Baldwin's effect was what is now called polyphenism, the tendency of some organisms to change their phenotype in response to certain environmental stimuli. (Gilbert's contention reduces the importance of the effect because polyphenisms typically offer a very limited set of morphological or behavioral options already in the genome. They certainly remove the possibility of any active or conscious learning to provide a mechanism for eventual genetic evolution.)

Hoffemeyer and Kull use the Baldwin effect as a starting point to argue for the importance of biosemiotics, the study of interpretation and communication in living systems. According to Hoffemeyer and Kull, semiotics operates in living organisms even at the cellular level, and it is at the root of intentionality ("aboutness"); semiotics therefore is crucial for the evolution of intelligence and for the operation of any type of Baldwinian effect. As a result of this recognition of the importance of symbol systems and representation in the evolutionary process, Hoffemeyer and Kull further recognize the inseparability of genetics and cognition in the evolutionary process. Reminiscent of the developmental systems theorists writing in Section Two, Hoffemeyer and Kull write, "Biologists have tended to underestimate the intricacies of the nurture project, thus failing to see the true challenge it poses to the understanding of genetics, in other words, to see, as Baldwin did, the true complexity of ontogeny as subtly determined by a non-additive interplay between genes and social minds" (p. 258).

The longest chapter in this book and, to my mind, the most interesting is Deacon's attempt to analyze the meaning of emergent phenomena (followed by Weber's discussion of the evolution of the mind as an example of this emergent process). According to Deacon, the Baldwin effect, and evolutionary processes more generally, "are a subset of processes drawn from a much larger set of novelty-producing processes that also includes self-assembly and self-organizing processes" (p. 273).

Like the developmental systems theorists, Deacon here is trying to advance the study of evolution beyond the reductionistic, genocentric modem synthesis perspective and toward a more complex model of evolution that incorporates all of the multifaceted processes that impinge on the ontogeny of an organism and the phylogeny of a species. What gave the modem synthesis such power as a paradigm for biology was the reduction of evolution to a few simple processes and the development of clear-cut constructs with which to describe and explain those processes. But this explanatory clarity was purchased at the cost of much of the richness and complexity that is inherent in the development of life. Deacon joins others who are developing the vocabulary and methods for moving beyond the reductivism of the modem synthesis into a biology that can confront life in all its complexity.

His project in this chapter is to develop the term emergence from "a promising abstract explanatory concept, but one that is at risk of becoming overused and too vague for any technical purpose" (p. 274), into a term with a more precise definition amenable to scientific use. Deacon proposes a three-level hierarchy of types of emergence, with first-order emergence referring to phenomena that can be thought of only at a level different from their constituent parts (such as surface tension of a liquid, which cannot be discussed in the same way as the individual molecules of the liquid). First-order emergence comes from the relationships among the individual components rather than from characteristics of the individual components themselves.

Second-order emergence is distinguished from first-order emergence by feedforward processes in which the current state of a first-order emergent object feeds information to both the micro-level and emergent-level systems of the object. As the object develops through time, its current state constrains its future development.

Third-order emergence adds information or memory. Second-order emergent objects can be recreated because their assembly is somehow encoded (e.g., in nucleic acids). This allows a selection process and the historical accumulation of features within lineages. Deacon suggests that all of these levels of emergence work together in the complex process of ontogeny and evolution.

A method that confronts this complexity will be necessary if we are ever to build a useful picture of the evolution of mental processes. For although evolutionary psychologists of the Cosmides, Tooby, Pinker, and Buss mold (e.g., Buss, 1995; Cosmides, Tooby, & Barkow, 1992; Pinker, 1997) have tried to account for specific cognitive phenomena from a modem synthesis and adaptationist perspective, they have done so by deliberately excluding both the physical underpinnings of the mind and the ontogeny of psychology as relevant to an understanding of adult cognitive function. These evolutionary psychologists have melded the functionalist assumptions of the cognitive revolution in psychology with the adaptationist perspective (Mayr, 1983; Williams, 1966) in biology (cf. Scher & Rauscher, 2003). For this reason, I (Scher, 2004) have called this form of evolutionary psychology cognitive adaptationism to contrast it with alternative approaches to evolutionary psychology that are being carried out by other scholars (cf. Caporael, 2001; Heyes, 2000; Laland & Brown, 2002; Moore & Michel, 1998; Scher & Rauscher, 2003).

Because of its focus on selection for genes that produce isolated adaptations, cognitive adaptationism largely ignores the process whereby having a gene for a particular feature (a questionable concept in its own right) leads to the appearance of that feature in the phenotype. The reliance on adaptationism leads to this neglect of ontogeny.

However, there may be a paradigm shift (to adopt Kuhn's [1970] problematic term) going on in biology today. More and more evolutionary biologists are recognizing that development is an important part of evolution. Evolutionary developmental biology (evo-devo) is forging a new synthesis, this time between evolutionary and developmental biology (Gilbert & Burian, 2003; Gilbert, Opitz, & Raff, 1996; Hall & Olson, 2003; Minelli, 2003; Raff, 1996).

This new synthesis incorporates into evolutionary biology the fact that the same or very similar genes can lead to quite different phenotypes. Evolutionary developmental biology recognizes the developmental constraints that conserve phenotype, but for this very reason, evo-devo can also identify how changes in the developmental process can loosen those constraints. Evo-devo is crucial in understanding evolutionary innovation and recognizing the suboptimal adaptations that have evolved.

Likewise, the important role played by homologies (different traits presumably all evolved from a common ancestor trait) is part of the evo-devo payoff. Homologies can be identified between species, as evidence of common ancestry. But they can also be identified within species, suggesting that a trait originally serving one function may have been duplicated and subsequently evolved for a second function.

Evo-devo moves the study of evolutionary novelty beyond the black box idea that new features arise through some unspecified mutation process. By studying in detail the way organisms change from zygotes to fully formed adults, evo-devo can identify points at which change leads to new phenotypic features. The change can include genetic change, but developmental change may hold equal importance. And here we return to the Baldwin effect. If acquired changes in the environment in which a species develops can perpetuate themselves, then those acquired changes become heritable, in the broad sense that they are passed on from one generation to the next. And thus we have the requirements for natural selection (variability and heritability).

What we have to give up, of course, is the population genetics definition of evolution as changes in the gene pool. A lack of one-to~me correspondence between genotype and phenotype means that the concept of a gene as an eternal replicator that is selected for makes no sense. If a gene (or, equivalently, a set of genes) produces a particular phenotype only under certain sets of circumstances, then it is this developmental system that evolves. After all, it is only a phenotype that gives an organism a greater or lesser chance of survival and reproduction, the currency of evolutionary fitness.

With this altered definition of evolution, ironically, the need for the Baldwin effect is weakened. If a phenotype is created in a complex dynamic between genotype, environment, and behavior, then the need for a specific factor that pushes behavioral changes into the genotype is irrelevant. Behavioral changes are already part of what is important in evolution: the formation of the phenotype.

As an introduction to these issues, Evolution and Learning: The Baldwin Effect Reconsidered is a difficult but rewarding read. It left me with a Jong list of questions and further references to read, but I expect nothing less from a good scholarly work.

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Note

I. Simpson's article, as well as articles by Baldwin, Morgan, Waddington, Hinton and Nowlan, and others, are reprinted in Belew and Mitchell (1996).

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