

Genetics, Plasticity, and the Evolution of Cognitive Processes

Gordon M. Burghardt

In this volume the emphasis has been on the diverse cognitive abilities of animals, the various ways that they can be studied in both the field and in captivity, and theoretical issues as to the number, kinds, mechanisms, and comparative distribution of such abilities. It is now generally accepted that cognitive abilities have evolved just as have other characteristics of animals, such as anatomical structures. If natural selection produces animals with abilities to cope better with problems in some areas of their lives than in others, we need to focus on the different abilities animals possess and the contexts in which they are expressed. Moreover, for cognitive abilities to evolve, individuals in a population must differ in their cognitive abilities (or in the processes underlying them) and these differences must have adaptive consequences. Rarely, however, has work on these issues been carried out using modern methods of quantitative genetics in nondomesticated species, and yet such work may be particularly useful.

The evolution of cognitive abilities can be considered a subset of the evolution of plasticity in behavior. Behavioral plasticity has recently become a major concern in evolutionary biology (e.g., Via et al. 1995), but psychological interest in the issue goes back at least as far as the "organic selection" promulgated in the late 19th century (Belew and Mitchell 1996). In this effect, selection acts on plasticity itself. This mechanism was, at the time, viewed as an elegant means of dealing with the then still potent Lamarckian views of many scientists who could not envision how natural selection on either instincts or structures could explain the diversity found in nature without the inheritance of acquired traits. Romanes (1883) and other theorists such as Herbert Spencer developed the neo-Lamarckian 'lapsed intelligence' theory. This theory aimed to explain how instinctive or 'hard-wired' behavior could have evolved by postulating that such behavior was initially experience-dependent or learned, subsequently encoded in the hereditary material, and transmitted as inherited 'instinct.' In essence, the non-cognitive evolved from the cognitive in terms of behavior, turning the typical evolutionary scenario on its head. Although the major thrust of organic selection was independently discovered by several eminent scientists (i.e., Baldwin, Poulton, and C. Lloyd Morgan) about 1896, today it is often simply called the Baldwin Effect (see Belew and Mitchell 1996). Waddington's theory of genetic assimilation (Waddington 1953) was a much later model in this vein and other more recent ones have been collected in Belew and Mitchell (1996).

However, attempts to study the Baldwin Effect empirically, rather than through simulations and models, has proven difficult. One reason for the difficulty is that measuring genetic/environment interaction in behavioral measures in natural populations is difficult (Plomin and Hershberger 1991), although knowledge of such interactions is critical to how populations adapt to changing circumstances both phenotypically and genotypically. In many species dietary selection is a major arena for the operation of plasticity, and it is known that variation in both genetics and dietary experience play important roles in responses to food (e. g., Burghardt 1993).

There are many reasons for the lack of research on the genetic bases of individual differences in cognitive abilities. First, comparative psychology was historically focused on species differences in 'intelligence' and ranking animals along some continuum. Here the search was for a key method producing a reliable measure of intelligence across species, assuming that there was such a single measure if only we could discover and measure it. Second, genetic studies necessitate large numbers of animals raised and tested identically and this was hard to accomplish with dogs, monkeys, cats, pigeons, and other typical lab animals. Small samples of animals of diverse genetic backgrounds were tested intensively and individual differences dismissed as noise or the effects of pre-training experiences, if noted at all. Species able to be reared and tested in large numbers were lab mice and rats, and these were typically strains or breeds quite highly inbred and so genetic differences were minimal. Crosses between breeds and selective breeding did show a genetic basis, as demonstrated in the pioneering