Good, bad, and ugly questions about heredity

Helmuth Nyborg
International Research Center for Psychoneuroendocrinology, Institute of Psychology, University of Aarhus, DK-8240 Risskov, Denmark
Electronic mail: *psynbo@dkarhe2.bitnet*

Models of nature-nurture interaction date back at least to the golden age of ancient Greece. The models have not grown sufficiently in sophistication, however, to accommodate recent findings, so a more dynamic, nonlinear approach is now called for.

Plato represented a moderate environmentalist position: Men are born noble but society can easily corrupt them. His colleague, Aristotle, was a convinced hereditarian: People are born different and the differences can and should be exploited by society. The medieval church claimed: Man is born with original sin, but a good Christian upbringing helps. Rousseau declared that we are savages born noble, but that we are corrupted by a less than perfect society. In early nature-nurture debate, the attitude of the participants *was* the evidence, exceptions went largely unnoticed, the nature of hereditary and environmental variables was left unspecified and the assumptions of independence and linear relationships were not tested. Nobility, sinfulness, and corruptibility eventually dropped out of the nature-nurture vocabulary because they were too elusive.

Other abstract variables took their place, however. The contemporary idea of heredity reflects a coefficient based on individual differences around a population mean. Interaction means statistical interaction. Statistics is used to determine how much of average development and functioning is due to the stabilizing (additive?) effects of genes and how much is due to (additive?) modifying effects of the environment. Gene effects are typically assumed rather than localized and specified. Environmental effects refer to social or cultural dimensions intuitively deemed important by the investigator.

One is left with the impression that the nature-nurture debate still operates at a very high level of abstraction and intuition. There is nothing inherently wrong with abstraction or calling things by names, but there must be a certain reality behind it. I suggest that the recent tremendous progress in molecular biology may help us better discriminate between fact and fantasy and distinguish the good, the bad, and the ugly questions about nature-nurture interaction.

From this point of departure, good questions are:

What are the chemical characteristics of the particular DNA material the fetus received from its father and mother?

What structural and chemical developmental effects did this particular combination of DNA give rise to bodywise and brainwise?

To what extent, through which mechanisms, and in which ways are the combined DNA actions influenced by well-defined physical and chemical influences of the environment and vice versa?

These are good questions because the variables can be operationalized and studied by the powerful tools of the natural sciences.

The question: "Why not assume that heredity and environment reflect well-defined, independent, and linearly related variables?" was not originally a bad question, because it led to preliminary evidence that genes count in development. But, it is ugly to continue on this track, as we now know that the idea of independence and additivity no longer holds, as illustrated so well by Wahlsten. The major question: "What is the relative contribution of heredity and environment in explaining the total phenotypic variability for a given trait?" is really a bad one, because (1) linear models obscure the existence of dynamic interactive relationships between heredity and environment, (2) statistical solutions are not likely to settle this problem, and (3) modern developmental biology now acknowledges the importance of nonadditive processes (Pritchard 1986).

Nonlinear models, however, may be quite difficult to apply. The adoption of such models by the natural sciences has led to much controversy, and parts of modern physics have become "entangled" (Glashow 1988). Can we expect similar chaos in the behavioral sciences after having docked linear nature-nurture models? Not necessarily. Dynamic nonlinear models for variable expression of genes have already been developed for the area of neuroendocrinology (Nyborg 1983; 1984) and seem able to explain rather complex aspects of the dynamic biphasic relationships between genes, hormones, body and brain development, functioning, and behavior (Nyborg 1988; 1989; submitted a; b; Nyborg & Boeggild 1989). Briefly, these models reflect the observation that a microscopic dose of sex hormone can selectively enhance or suppress the protein production of thousands of genes, with cascades of early organizational and later activational effects on the development and functioning of body and brain and, accordingly, on behavior. "Optimal" development and functioning seems to depend on intermediate plasma sex hormone concentrations. Lower and higher plasma concentrations both have detrimental effects although for different reasons. Further process nonlinearity arises because the actions of sex hormones are highly sensitive to certain changes in environmental conditions and to the considerable variation in receptor availability, sex hormone binding globulins, and turnover rate. All this speaks for treating each individual as a self-contained dynamic system of processes that interacts with its surroundings in nonlinear ways but within limits set by its DNA material, by ongoing physiological processes, and by the character of environmentally modulated changes in neurotransmitters, including those caused by other people. Temporary high-level stress in a pregnant woman may, for example, permanently switch myriads of fetal genes on or off, with profound long term effects on development and functioning.

All this illustrates what is wrong with traditional models. Assumptions of independence and additivity are often violated, and they lack precision about the character, mechanisms, and locus of action of the relevant causal variables. They group individuals by the thousands, use averaging population statistics, and then make implicit inferences about individuals. The new model will focus first on the chemical and physical agents and physico-chemical processes that make each individual different and then look for communalities (Nyborg 1977, 1987).

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* Present address: Laboratory of Neuroendocrinology, Rockefeller University, New York, NY 10021-6399.

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