A developmental science commentary on Charney's "Behavior genetics and postgenomics"

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Abstract:

Charney's target article convincingly demonstrates the need for the discipline of quantitative human behavior genetics to discard its false assumptions and to employ the techniques, assumptions, and research program characteristic of modern developmental psychobiology.

Keywords: commentary | quantitative human behavior genetics

Article:

Charney provides a timely assessment of how research in molecular genetics challenges most of the assumptions of the quantitative behavior genetics of humans and requires a reorientation of that research program (a paradigm shift). The physical instantiation in the DNA of the hypothetical gene of quantitative genetics has altered notions of how genes work and these changes affect how genes can be used as descriptive and explanatory constructs in quantitative genetics. I propose that the research program of developmental psychobiology can serve as the context for the "new" paradigm.

The discipline of quantitative genetics was proposed as an alternative to the qualitative/descriptive approach of Darwinian theory. The interpretation offered for Mendel's research proposed that the hypothetical hereditary elements (genes), provided by the parent population, specified the particular characters of individuals. These genes segregated independently to produce the offspring's characters and linked the offspring's and parents' features. The genotype–phenotype distinction highlighted the hypothetical aspect of the "gene" construct and its incomplete relation to observable traits. Quantitative genetics became the discipline capable of characterizing the heredity of traits and predicting their distribution in an offspring population given knowledge of their distribution in the parent population and who mated with whom.

Before the establishment of quantitative genetics, Galton (1869/1891) proposed the techniques (e.g., comparison of the correlations among monozygotic [MZ] and dizygotic [DZ] twins) for investigating the heredity of human psychological traits (e.g., intelligence, personality). Galton's techniques were combined with those of quantitative genetics to create

quantitative human behavior genetics. Given the individualistic character of Western cultures (which values the notion that the individual's self, personality, and abilities owe little to cultural and social contexts), a popular belief in genetic determinism became the context in which human quantitative behavior genetics flourished.

The modern synthesis combined Darwinian theory of evolution by natural selection with quantitative genetics. Natural selection worked on phenotypic traits, but these traits reflected the combination of specific genes inherited from the parents that governed their developmental manifestation. The modern synthesis supposedly incorporated developmental phenomena by acknowledging that genes and the environment interact to create the traits. Fisher's analysis of variance techniques estimated the influence of genetic and environmental factors and the interaction of genes and environment on phenotypic variability (Fisher 1925). Some developmental scientists argued that complex organisms develop through interactions at many levels of organization within the organism and in relation to the external environment in ways not captured by Fisher's technique.

Quantitative geneticists developed procedures that permitted them to ignore research attempting to characterize mechanisms responsible for the development of traits. They assigned such mechanisms to only three sources of variance: genetic influences, environmental influences (including shared and non-shared environments), and the influences of genetic × environmental interactions. Behavioral genetic research on humans used the same models to create the impression of a genetic predisposition and susceptibility of individuals to certain environmental risk factors in the development of particular psychological phenotypes. Unfortunately, these models do not account for how some individuals with both the presumed predisposition and exposure to the environmental risk do not manifest the phenotype. Nor do the models account for how other individuals, with neither the presumed predisposition nor the environmental risk, nonetheless manifest the phenotype. In contrast, developmental scientists were seeking to account for those changes in developmental trajectories that characterize the manifestation of all such types of phenotypic traits (developmental psychobiology).

Meanwhile, as researchers tried to instantiate the hypothetical genes, chromosomes became the first candidate. Discovery that chromosomes are composed partly of the DNA molecule and that DNA was a double helix whose strands could unwind and separate to form two identical DNA molecules demonstrated how gametes could retain hereditary components from each parent. Further discovery that particular triplet sequences of the four bases of the DNA could "code" for a specific amino acid and that proteins were specific combinations of amino acids gave the promise of a complete material instantiation of genes. As Charney's article nicely illuminates, molecular instantiation of genes began to create problems for the quantitative geneticists' assumptions about how genes operate.

When molecular genetics failed to provide evidence of direct relations of genes to behavioral phenotypes, quantitative geneticists proposed that complex traits could be connected to genes via endophenotypes. The term endophenotype describes the various physiological pathways that relate the genotype to behavioral phenotypes (Gottesman & Gould 2003). Brain structure and functioning were key endophenotypes that were "causal mechanisms leading to specific [psychological] outcomes" (Maheu & Macdonald 2011, p 20). Genes would affect mechanisms of cellular functioning which, in turn, would bias developmental trajectories via their influence on protein production and subsequently on neural structure and function. Thus, the endophenotype acknowledges that a complex pathway (developmental) channels genotypes into a delimited range of possible phenotypes.

Of course, endophenotypes are themselves affected by environmental factors. Elucidation of such patterns of organism–environment interaction during development is the research program of developmental psychobiologists (Michel & Moore 1995). Developmental psychobiology provides research strategies that reveal the dynamic bidirectional relationships between the individual's biological processes (including molecular genetics) and the individual's social and physical environment at all levels of organization in the developing individual. Research in developmental psychobiology demonstrates how specific behavioral characteristics derive from trajectories that represent transitions in the individual's biological processes as these are affected by the individual's environmental conditions, at each specific phase of the trajectory.

Epigenetic regulations of gene activity and expression are only one manifestation of this organism–environment interplay during development. Deconstructing the various contributions to the dynamic of this developmental process has been the activity of developmental psychobiologists. Genes (molecular cellular processes) play a part throughout these developmental trajectories. However, developmental psychobiologists have demonstrated that the offspring also inherit an ecological habitat (niche), a pattern of parental care for many species, and the epigenetic factors created by the parents' life conditions. Thus, someone's psychological phenotype is a product of a uterine and postnatal nurturing environment that is influenced by nutritional, stressful, and particular social and physical experiences operating within specific cultural and societal conditions.

Developmental psychobiological research strategies require elaborate and extensive longitudinal research designs using robust statistical tools. However, they produce advances in knowledge of what maintains consistency across development and what produces changes in trajectories and this knowledge will eventually reveal effective intervention techniques for prevention and rehabilitation of certain psychological phenotypes. This knowledge will inform social-policy-relevant discussions (e.g., for educational programs, treatment of disorders, adjusting social stratification, decision making and conflict resolution).