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2014 : WHAT SCIENTIFIC IDEA IS READY FOR RETIREMENT?

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Behavior = Genes + Environment

Would you say that the behavior of your computer or smartphone is determined by an interaction between its inherent design and the way it is influenced by the environment? It's unlikely—such a statement would not be false, but it would be obtuse. Complex adaptive systems have a nonrandom organization, and they have inputs. But speaking of inputs as "shaping" the system's behavior, or pitting its design against its input, would lead to no insight as to how the system works. The human brain is far more complex, and processes its input in more complex ways, than human-made devices, yet many people analyze it in ways that are too simplistic for our far simpler toys. Every term in the equation is suspect.

Behavior: More than half a century after the cognitive revolution, people still ask whether a behavior is genetically or environmentally determined. Yet neither the genes nor the environment can control the muscles directly. The cause of behavior is the brain. While it is sensible to ask how emotions, motives or learning mechanisms have been influenced by the genes, it makes no sense to ask this of behavior itself.

Genes: Molecular biologists have appropriated the term "gene" to refer to stretches of DNA that code for a protein. Unfortunately, this sense differs from the one used in population genetics, behavioral genetics, and evolutionary theory, namely any information carrier that is transmissible across generations and has sustained effects on the phenotype. This includes any aspect of DNA that can affect gene expression, and is closer to what is meant by "innate" than genes in the molecular biologists' narrow sense. The confusion between the two leads to innumerable red herrings in discussions of our makeup, such as the banality that the expression of genes (in the sense of protein-coding stretches of DNA) is regulated by signals from the environment. How else could it be? The alternative is that every cell synthesizes every protein all the time! The epigenetics bubble inflated by the science media is based on a similar confusion.

Environment: This term for the inputs to an organism is also misleading. Of all the energy impinging on an organism, only a subset, processed and transformed in complex ways, has an effect on its subsequent information processing. Which information is taken in, how it

is transformed, and how it affects the organism (that is, the way that the organism learns) all depend on the organism's innate organization. To speak of the environment "determining" or "shaping" behavior is unperspicuous.

Even the technical sense of "environment" used in quantitative behavioral genetics is perversely confusing. Now, there is nothing wrong with partitioning phenotypic variance into components that correlate with genetic variation (heritability) and with variation among families ("shared environment"). The problem comes from the so-called "nonshared" or "unique environmental influences." This consists of all the variance that is attributable neither to genetic nor familiar variation. In most studies, it's calculated as 1 – (heritability + shared environment). Practically, you can think of it as the differences between identical twins who grow up in the same home. They share their genes, parents, older and younger siblings, home, school, peers, and neighborhood. So what could make them different? Under the assumption that behavior is a product of genes plus environment, it must be something in the environment of one that is not in the environment of the other.

But this category really should be called "miscellaneous/unknown," because it has nothing necessarily to do with any measurable aspect of the environment, such as one sibling getting the top bunk bed and the other the bottom, or a parent unpredictably favoring one child, or one sibling getting chased by a dog, coming down with a virus, or being favored by a teacher. These influences are purely conjectural, and studies looking for them have failed to find them. The alternative is that this component actually consists of the effects of chance – new mutations, quirky prenatal effects, noise in brain development, and events in life with unpredictable effects.

Stochastic effects in development are increasingly being recognized by epidemiologists, frustrated by such recalcitrant phenomena such as nonagenarian pack-a-day smokers and identical twins discordant for schizophrenia, homosexuality, and disease outcomes. They are increasingly forced to acknowledge that God plays dice with our traits. Developmental biologists have come to similar conclusions. The bad habit of assuming that anything not classically genetic must be "environmental" has blinkered behavioral geneticists (and those who interpret their findings) into the fool's errand of looking for environmental effects for what may be randomness in developmental processes.

A final confusion in the equation is the seemingly sophisticated add-on of "gene-environment interactions." This is also designed to confuse. Gene-environment interactions do *not* refer to the fact that the environment is necessary for genes to do their thing (which is true of all genes). It refers to a flipflop effect in which genes affect a person one way in one environment but another way in another environment, whereas an alternative genes has a different pattern. For example, if you inherit allele 1, you are vulnerable: a stressor makes you neurotic. If you inherit allele 2, you are resilient: a stressor leaves you normal. With either gene, if you are never stressed, you're normal.

Gene-environment interactions in this technical sense, confusingly, go into the "unique environmental" component, because they are not the same (on average) in siblings growing up in the same family. Just as confusingly, "interactions" in the common-sense sense, namely that a person with a given genotype is predictably affected by the environment, goes into the "heritability" component, because quantitative genetics measures only correlations. This confound is behind the finding that the heritability of intelligence increases, and the effects of shared environment decrease, over a person's lifetime. One explanation is that genes have effects late in life, but another is that people with a given genotype place themselves in environments that indulge their inborn tastes and talents. The "environment" increasingly depends on the genes, rather than being an exogenous cause of behavior.