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EVIDENCE IN THE SCIENCES OF BEHAVIOR

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The behavioral sciences—psychology, sociology, ethology—have been characterized by multiple schools, multiple approaches, multiple theories. So much is this so, that some are tempted to dismiss these sciences as either not science at all or as at best pre-scientific, lacking as they do a single paradigm. But the multiplicity of approaches and consequent debates about them cannot so easily be avoided, because the debates concern what is to be measured or modeled, and how and why. The label *pre-scientific*, furthermore, is misleading. There is a great deal of activity qualifying as science by any definition that is occurring throughout the broad range of behavioral sciences: various kinds of observation, measurement, experiment, and hypothesis evaluation. The source of discord may lie partly in the complexity of the phenomenon, rather than in the immaturity of the research. It may also lie in false expectations: the hope that there is a decidable empirical basis for all policy questions and the hope that evidence can be decisive regarding all issues in the scientific study of behavior.[1]

Research on both causal and compositional questions can proceed in a top-down direction or a bottom-up direction. Top-down research identifies a behavior of interest (e.g., aggression); characterizes the behavior in a way that makes it amenable to study; finds appropriate measures of the behavior; and then seeks correlates in lower-level behaviors or temperamental characteristics, and ultimately in biological factors such as neural states, non-neural physiological states, or genes. Bottom-up research studies the etiology of lower level factors, such as temperamental components (e.g., impulsivity) or neural states, neuro-active substances, and non-neural physiological states,

and seeks correlates of these at the behavioral level. The challenge to researchers is to design measurement and observational protocols sensitive enough to pick out significant relationships and to differentiate between possible causal factors.

In the public eye, the big question about behavior is the nature versus nurture question: Is behavior B a result of our genes or our upbringing? Although it looks as though there is one question that multiple approaches are asking—what is the cause of x?—on closer examination there are quite different kinds of causal question that are asked within the different approaches. The debates among proponents of different approaches, even when articulated as debates about different causal theories, are at least as much, if not more, about the point or value of different kinds of knowledge.

In this chapter, a prolegomenon to a more extensive analysis of this research, I wish to dispel the idea that there is an empirical way of settling disputes among proponents of the different approaches, by showing that each approach generates its own set of questions, to which different forms of data can provide answers. Even though some hypotheses supported within the different approaches seem to be in contradiction, the conflict is not, or not always, one that can be settled by appeals to evidence. Instead, the disagreements are best understood as conflicts between approaches. At the minimum, an approach includes characteristic questions, characteristic methods for addressing those questions, and a commitment to the importance of the questions and the answers generated by the available methods.

First, I describe each of a set of approaches to studying behavior in a general way, noting whatever explicit theoretical framework is adopted and what kind of knowledge is sought. I then look more closely at the questions and methods of answering them to consider the import of the available and possible evidence. Finally, I suggest an alternative way to cast the disagreements between the advocates of the different approaches.

Four Approaches to Studying Behavior

Behavior Genetics

Behavior genetics includes both quantitative (or classical) behavior genetics (the application to behavior of population genetics) and molecular behavior genetics (the application of molecular genetics to behavior). Granting that both the genes and the environment of an organism causally influence its behavior, the behavior geneticist asks what the genetic contribution to a given behavior is. The main tool that is used is analysis of variance, that is, identification of how much of the difference

in expression of a trait in a population is correlated with genetic difference. This requires being able to separate or distinguish differences in environment from differences in genotype, as well as to specify what counts as sameness.

In humans, the methods traditionally used have been twin studies and adoption studies, in which one or another of the contributing factors is purportedly held constant in order to measure differences in the other. Researchers have compared the degree of similarity (concordance) in expression of a given trait by monozygotic (MZ) twins who share an identical genotype and by dizygotic (DZ) twins who share only half of their genes. The assumption is that the environment is the same for the members of the DZ twin pairs, and that only the genotype differs. A finding of higher concordance in a trait among MZ than among DZ twins is treated as data supporting claims of heritability of that trait. Researchers have also compared twins reared apart with twins reared together. Here the assumption is that the environments differ for the separated twins and not for the twins reared together, whereas the genes in both kinds of pair remain the same. In adoption studies, researchers compare adoptees with both their biological and their adoptive parents, and sometimes with biological and adoptive siblings. While most proponents and commentators understand quantitative behavior genetics as applicable to differences within populations, some have argued that it can also be used to determine the genetic contribution to individual development as well.[2]

A typical quantitative behavior genetics study of aggression measures concordance in some indicator of aggressive behavior, such as felony conviction or antisocial personality diagnosis, among biologically related family members in comparison with non- or less-biologically related family members, whether MZ versus DZ twins or biological versus adoptive parents and siblings.[3] Researchers Mason and Frick identified 70 such studies of aggressive behavior (that did not involve confounding issues such as alcohol abuse) published between 1975 and 1991.[4] They developed a set of selection criteria that the studies had to satisfy in order to be included in a meta-analysis. They then sorted the behaviors reported in the studies into three categories: criminal offending, aggression, and (other) antisocial behavior. Each of these was then divided into the categories "severe" and "non-severe." According to Mason and Frick, the studies supported the conclusion that there are genetic effects on antisocial behavior, and that these are stronger for severe antisocial behavior than for the non-severe.

Behavior genetics has recently acquired another research tool, thanks to molecular genetics: linkage analysis. Linkage analysis looks for common genetic markers in biological relatives identified as sharing the same behavior. The markers are known multi-allelic loci on a given chromosome. The

strategy is to associate allelic variation with behavioral variation. If such an allelic association can be found, that is taken as evidence that a gene in the same region of the chromosome is involved with the behavior.

In 1993, 14 male volunteers of a Dutch family, all of whom experienced episodes of aggressive behavior, were found also to share genes on the X chromosome coding for a particular enzyme: monoamine oxidase, or MAOA.[5] Also in 1993, Dean Hamer and colleagues at the National Institutes of Health announced that pedigree analysis showed an elevated incidence of homosexuality in brothers of gay men (13.5%) and in maternal uncles and sons of maternal aunts of gay men (7.5%).[6] This incidence, given the size of the sample, is significant if one assumes a background rate in the general population of 2%. The pedigree analysis suggested X chromosome involvement. Linkage analysis revealed common markers at the Q28 locus of the X chromosomes in 33 of 40 sibling pairs selected from the larger sample. As with twin and adoption studies, the interpretation of results like these is controversial. Behavior geneticists interpret the twin and adoption studies and linkage studies as indicating that there is a significant heritable (and when backed by linkage analysis, genetic) component in the behaviors studied.

Human behavior genetics is buttressed by a variety of studies on nonhuman animals. In a research process known as reverse genetics, a form of bottom-up research, researchers introduce mutations into the genome and identify the consequent variations in behavioral routines. These studies, performed largely on organisms such as varieties of *drosophila*, can be used to suggest mechanisms of gene expression, as well as behaviors in other organisms (e.g., humans) possibly subject to genetic influence.

Proponents of behavior genetics claim on its behalf that it can help elucidate the mechanism's underlying behavior; that it represents the appropriate extension of evolutionary—Darwinian—concepts to behavior; that it can help show the role of non-genetic, environmental factors in behavior; and that it can indicate the limits of various kinds of intervention strategies, as well as identify the populations that may or may not benefit from such strategies.[7]

Social-Environmental Approaches

The social-environmental approach emphasizes the environmental contribution to the development and expression of various behaviors.[8] Socially or environmentally oriented studies seek to establish the role of socialization patterns, familial and school environments, peer relations, media exposure, and/or parental attitudes and interactions with their children. The methods used include correlational studies (using information gleaned from various public records and from interviews and surveys) and the direct observation of behavior and interactions in standardized (laboratory) settings. Typically, the subjects in these studies are young children or adolescents, although in some cases the adult behavior of persons identified as having had a certain kind of experience in childhood is also studied. Path analysis is used when many variables are being examined. In some cases, researchers conduct longitudinal studies, following individuals for six or more years. The young and adolescent subjects for these studies are identified in schools or through clinics.

In one such study, researchers sought to correlate familial interaction patterns with long-term disruptive behavior in eight- and nine-year-old boys. The boys were identified by teachers, who were asked to complete Social Behavior Questionnaires on their students. Interactions in 44 families were studied by observing the parents and child in question engaged in joint tasks in the researchers' laboratory. Observers used checklists in rating dyadic interactions between father and child, mother and child, and between the parents. Researchers found that negative behaviors (such as verbal abuse or attacks) and positive behaviors (such as endearments) in the parent-child dyads were not reciprocal, but that negative behavior of one parent toward the boy was correlated with negative behavior on his part toward the other parent. In addition, negative behavior of boys toward their mothers was correlated with fathers' negative attitudes toward their female spouses.[9]

Until recently, a great deal of the literature in psychology and sociology on social-environmental determinants of homosexual orientation was articulated in the context of a disorder or deviance model of homosexuality. (Homosexuality was not removed from the American Psychiatric Association's list of psychiatric disorders until the 1970s.) Accordingly, this literature has explored such factors as the overprotective mothering of boys and has focused on sexual behaviors in Western societies. Anthropological cross-cultural studies offer another perspective, as well as an alternative to the individualistic approaches to behavior found in other approaches. Barry Adam, reviewing a number of studies, proposes that in certain social configurations, homosexuality is an outgrowth of particular combinations of age, gender, and kinship structures.[10]

Practitioners of social-environmental approaches have various views about what can be concluded from such research and what the point of it is. Some researchers clearly assume a causal effect of parental behavior on children.[11] Others acknowledge that in the networks of association their studies uncover, causal relations might go differently than they assume them to.[12] Diana Baumrind takes something of an equivocal (perhaps strategic) position: causal inferences are not licensed by the correlational

data produced in these studies.[13] Such data are valuable for eliminating, but not confirming, hypotheses. Nevertheless, she claims, it is reasonable to conclude on the basis of a number of studies that parental behavior does influence children's development. This being the case, these environmentally oriented studies are valuable because they can (help to) identify children "at risk" of antisocial behavior or delinquency and identify points of intervention in family and school dynamics. And in a clearly melioristic declaration of faith, she says that even if heritability accounts in large part for what is, it doesn't follow that social interventions can't improve on that. The implication is that social-environmental research approaches are required to identify which social interactions are effective.

Developmental Systems Theory

The developmental systems approach has its theoretical base in embryology and developmental biology. Here the central question is how the organism develops from a single fertilized cell into a mature individual characterized by multiple and specialized organs and tissues. Differentiation, the process of specialization of cells, is one of the key problems for developmental biologists. For the systems approach, genetic and environmental contributions to development are not separable. The relation between them is non-additive and nonlinear. Nor can behavioral development be separated from the other dimensions of development.

Gilbert Gottlieb, one of the principal researchers in this tradition, characterizes development as emergent, coactional, and hierarchical.[14] By hierarchy, Gottlieb seems to mean the multilevel character of development and the interlevel, as well as intralevel character of coaction. "Hierarchy" is not used to convey dominance or causal priority, but rather the unity of genetic, physiological, neurological, behavioral, and environmental aspects of the developmental system. It is being used, therefore, much as Grene and Eldredge (1992) used it to represent something like degrees of embeddedness, or of enclosure.[15] By "emergent," Gottlieb means that structural and functional complexity increases at all levels of organization of the individual as a result of interactions within and between these levels. By "coactional," Gottlieb means that the factors involved in development interact. Not only do these factors not act independently, but they can also modify one another, thus altering their respective contributions in subsequent phases of development.

A variant of the Developmental Systems approach is the Dynamic Systems approach. The difference, if any, lies more in emphasis. Whereas the Developmental Systems advocates stress the complexity of interaction of endogenous and exogenous factors, the Dynamic Systems advocates

stress their temporal nature: the dependence of one stage of development on earlier stages. Esther Thelen's research offers one of the few examples of the application of this approach to the study of human behavior.[16] She has studied the development of basic motor skills, such as reaching and grasping in infants, skills that involve cognitive, neural, and muscular coordination. Her research involves systematically varying elements of the situation implicated by the components of such skills by, for example, changing the contents of the perceptual environment, altering the speed at which objects move in that environment, measuring arm angles and wrist torque, altering constraints on muscles (with weights), and repeating these variations over time to see how the organism learns to integrate component capacities into coherent behaviors.

Developmental systems theorists see the point of their work as producing a comprehensive understanding of the mechanisms of development. The object of their interest is the individual organism, not populations. For them, the core questions are those of differentiation. In the realm of behavior, this means understanding how some behaviors are canalized—that is, fixed—while others remain malleable throughout an individual's lifetime. Researchers seem less concerned about practical applications such as interventions, although some have argued that there are implications of taking the systems view. Lerner argued that a systems or contextual approach, because it involves a finer attention to differences between individuals and between environments, requires abandoning notions of the "generic child" (which tends to be a white middle-class child) in the design of social intervention strategies.[17] Instead, researchers and clinicians should take into account contextual variability (both variation in developmental contexts and variation in the interactions of different individuals in the same context). This insistence on variability and context dependence means that, if generalizations are to be obtained within this approach, they will not be generalizations about populations, individuals, or their properties, but generalizations about processes. Such generalizations will be about more abstractly conceived entities such as canalized behavior, rather than about aggression or sexual orientation per se.

Neurophysiological and Neuroanatomical Approaches

Neurophysiological and neuroanatomical approaches to behavior seek to identify and characterize aspects of the neural substrate of behavior. The Decade of the Brain (1990–2000) in the United States encouraged and funded a great deal of research on the human brain and nervous system. Thus much more is known about the brain than was known before. Nevertheless, it's not clear that our overall understanding of brain function has kept pace,

since that would require integrating the disparate bits obtained by the methodologies such as electroencephalography and the newer imaging technologies. Although there are some general theories of brain function, such as the neuronal group selection theory advanced by Gerald Edelman, that drive experimental programs, the latter tend to be either research on cognitive function or research at the molecular level.[18] Research on neural correlates of aggression and of sexual orientation does not seem part of any specific theory of brain function, but is carried out under the not-unreasonable assumption that accounts of brain and neural function will be part of any complete account of the mechanisms of behavior.

There is a vast literature detailing experiments with laboratory animals with respect to both aggressive and sexual behavior. Recent work on humans takes advantage of new imaging technologies such as PET (positron emission tomography) and NMRI (nuclear magnetic resonance imaging), as well as new developments in neurochemistry and neuropharmacology. In addition, some studies use traditional methods, such as postmortem dissections, for structural information. Work on laboratory animals involves manipulating levels of neuroactive substances and observing the effects of those manipulations on animal behavior.

As an example of animal studies, the laboratory of Craig Ferris has been studying the role of vasopressin and vasopressin antagonists in enhancing or decreasing the expression of highly stereotyped forms of aggressive behavior in several rodent species.[19] Here the interest is in understanding the functions of vasopressin in the organism. Not only behavior, but also internal effects such as binding to specific sites in the hypothalamus are studied. Stereotyped behaviors, such as flank marking, are good indices of behavioral effects, just because their stereotypical nature makes them easy to observe and identify. Thus aggression is of secondary interest in this research—any behavioral effect that is easy to study would do as well.

When the research involves human subjects, the situation is not so straightforward. Serotonin, a neurotransmitter, was first studied in nonhuman animals, rodents, and later rhesus monkeys.[20] There it was found to be inversely related to irritability—understood as a tendency to respond aggressively to adverse stimuli—which suggested a similar role in humans. The role of the serotonergic system—the process of neurotransmitter release and reabsorption (metabolism)—in a variety of dysphoric conditions has been studied via three primary methods in humans. Concentrations of serotonin metabolites can be measured in cerebrospinal fluid, with reduced concentrations of the metabolites signaling decreased serotonin activity. Also, there are strategies for indirectly measuring the presynaptic sites of serotonin reuptake (*reuptake* means lower levels of serotonin activity). And finally, "pharmacochallenge" studies involve administering pharmaceutical agents,

especially serotonin agonists or mimics, to study serotonin activity in the brain (e.g., the specificity of receptor sites).[21] All three of these methods support the conclusion that diminished serotonin activity is associated with (impulsive) aggressive and antisocial behavior.

Neuroimaging strategies are used to identify areas of greater or lesser activity in the brain. Computerized tomography and magnetic resonance imagery provide structural information. The former uses X-rays passed through an individual's head from multiple positions to create an image. The latter disturbs hydrogen ions with radio waves and employs a magnet to realign the ions. Differences in resonance frequencies emanating from different tissues in the brain are then used to create the image. Regional cerebral blood flow (rCBF) studies use inhaled or injected xenon or similar tracers to detect areas of enhanced blood flow and, by inference, increased activity. Positron emission tomography (PET) assesses rates of glucose metabolism by means of a radioactive tracer that leaves a residue, which can be detected by a scanner, at sites of metabolic activity. In both MRI and PET the better resolution is obtained from the much more costly instrument, thus limiting the sample sizes in those studies. And the data obtainable from the different strategies are not always correlated, so any information gained by these strategies must be regarded as preliminary.[22]

Nevertheless, researchers are attempting to link dysfunction in particular brain areas with particular forms of aggressive or assaultive behavior. For example, Adrian Raine and colleagues used PET scanning to study the brains of persons charged with murder who were referred to psychiatric clinics in preparation for insanity defenses or a determination of competency to stand trial.[23] They found diminished prefrontal cortical function in that group, as compared with matched controls, and similar levels of function in other brain areas in the two groups, leading them to conclude that prefrontal cortical dysfunction could be implicated in violence in some offenders. They caution that the sample was small and consisted of individuals already suspected of mental illness or organic brain injury.

Both functional and structural studies have been performed in connection with sexual orientation. In the 1990s, Simon LeVay reported on a comparative study of brain structure in heterosexual and homosexual patients who had died of AIDS.[24] LeVay chose to focus on the medial preoptic area of the anterior hypothalamus, because that area had been identified as involved in sexual behavior in rats. Although he found that one set (of four) of the nuclei in the homosexual men's brains were closer in size to those of the (undifferentiated with respect to sexual orientation) women's brains than to those of the heterosexual men's brains, those nuclei are not ones identified as sexually relevant in the rat studies. The significance of these findings is thus not known.

Quite obviously, the point of studies of these kinds is better to understand the neural substrate of human behavior and action. In this regard they can be seen as part of the much larger research program of the neurosciences, but focused on understanding the function of particular aspects of the brain and nervous system, such as particular neurotransmitters or particular structures. The large gap between measurable changes in these features and changes in particular associated behaviors, however, means that this work is in its very early stages. Furthermore, although in some cases (e.g., injury that alters structure or function, followed by a change in behavior) the direction of causality can be fairly confidently affirmed, in others the causal relations among empirically associated phenomena are still unknown. This is true of most of the work on aggression and of the work on sexual orientation. Since in both cases the functional and structural differences could be consequences of behavior that has been canalized by other factors, its causal role cannot be unproblematically inferred.

But the work done specifically on aggression also has a variety of pragmatic purposes. The work on serotonin, for example, informs psychopharmacological interventions such as the administration of Prozac or other agents to aggressive individuals. It thus is implicated in both medical and commercial networks, with corresponding social and political reverberations.[25] This work, as well as the neuroimaging and physiological research, also suggests the need to distinguish among subcategories of aggressive individuals, some of whom may have biologically based dispositions that are either toward aggression or will be expressed as aggression under certain conditions. Low-impulse control, for example, crops up in a number of studies as a differentiating feature associated with various functional or structural differences.

Preliminary Analysis of the Structure of Investigation

Comparative examination of the studies carried out in these different families of investigation shows that distinctive questions stimulate the development of distinctive methodologies. Here is a more systematic presentation of these components of the respective investigations.

Questions

What appear to be the common or umbrella questions—What causes behavior? What is the most significant factor in the fixation of behavioral dispositions?—cannot be directly answered. Questions about behavior must, therefore, be more carefully and precisely articulated. They must also be articulated in the vocabulary of the state of the art at the time. The consensus is that both genes and environment, or both endogenous and exogenous factors, influence behavior. This means that a number of questions can be generated, each of which in turn produces a cascade of further questions. Each of the approaches discussed can be distinguished by a single question from which others follow, as in the list below:

What role(s) do genes play in behavior B?

- How much of B is genetically influenced?
- To what degree is B heritable? (How much are differences in parents correlated with differences in offspring? How much do differences in parents influence differences in offspring?)
- How much of the difference in expression of B in a population is associated with genetic difference?
- Does the degree of genetic influence on B change over time?
- How can the methodologies used to study the genetic influence on behavior (twin and adoption studies) be refined and extended?
- Can any genetic markers be associated with the incidence of B in a given pedigree?
- Can linkage analysis be refined and extended to strengthen claims of genetic influence?

What role do environmental and other exogenous factors play in behavior B?

- What role do gross- or macro-level social variables (such as social class; ethnic, racial, and cultural identity; urban/suburban/rural orientation; immigrant/native status) play in the expression/frequency of B? Does one or more of these predominate in the expression of B?
- What role do micro-level variables such as family, school, peers, or media exposure play in the expression of B? Does one or more of these predominate in the expression of B?
- Does the influence of micro-level variables in the expression of B vary in relation to macro-level variables? How?

- How do differences within a family influence the expression of B by its members?
- How can familial interactions relevant to B be studied?

How does B come to be expressed in individuals?

- What developmental trajectories can be identified that culminate in B?
- What developmental factors (genetic, epistatic, intrauterine, physiological, physical and social environment) interact in the development of B?
- Is the disposition to B canalized? If so, how?
- At what levels of organismic integration and organization do the causal/developmental processes relevant to B occur?
- Does the development of species-typical traits differ from the development of individually variable traits? (Of which type is B?)
- How do complexity of organization and specialization of function develop?
- How can intralevel and interlevel interactions be studied?

What role do neural structures and processes play in behavior B?

- Can a specific, local neural structure or process be associated with occurrences of B?
- Are the neural processes associated with B distributed or local?
- How are the processes associated with B activated? How are they inhibited?
- How do the processes associated with B interact with other neural and organic processes?
- How can available techniques be improved to study the role in the expression of B of the neural processes associated with it?

Each of the listed subquestions also generates additional questions as researchers go about answering them. Although this is especially true of the methodological questions, the substantive questions are also refined as research proceeds. There are, of course, questions that cross approaches. One could ask, for example, how genetic and environmental factors interact, or how neural and other factors interact. Only the developmental systems theorists attempt explicitly to address questions about interaction, and then only in the context of developmental questions. The questions just listed, however, can be pursued independently of whatever progress or lack of it is occurring in the other approaches. Each approach becomes self-sustaining through the modification of its questions in practice and by the consequent generation of more and more refined questions. The research programs derived from an initial question are thus driven further into specificity and autonomy.

Methods

One of the critical methodological issues is the identification, individuation, and definition of behaviors and of the causal factors contributing to their expression. A second issue is how to measure and establish the relatedness of the phenomena under investigation. Here I focus on the second of those issues.[26]

Behavior Genetics

Although there is a common overall question (thesis) as noted above, behavior genetics now encompasses at least two sorts of approach, each with a distinctive set of methods. Classical human-behavior geneticists use traditional methods of ascertaining heritability: twin studies and adoption studies. More powerful experimental methods, such as the breeding used in classical fruitfly genetics, are not appropriate for human studies, for reasons of both ethics and scale. Although they are carried out under the rubric of genetics, what twin and adoption studies can show at best is the extent of heritability of a trait in a given population, in a given common environment.

So the question to which twin studies can provide answers is, "How much of the difference in the expression of B in environment E is heritable?" The assumption is that "heritable" here is equivalent to "genetically heritable." Alternative or competing hypotheses would assign different heritability quotients. The studies cannot, however, be generalized to answer the question, "How much of the difference in the expression of B is heritable?" Both the variability and heritability of a trait can change when environments change. Thus, critics emphasize that twin studies do not enable conclusions about

causation in individual organisms, but only about distributions of a behavioral trait in a population in a given environment. Multivariate analysis can assist in the decomposition of complex traits, and longitudinal studies can help in identifying shifts in the relative influence of heritable and non-heritable factors over time. But twin studies are not capable of distinguishing between intrauterine and genetic effects. And because all that is known about twins is that they share a genome, they are not capable of distinguishing between polygenic and monogenic traits, nor, obviously, are they able to identify genes.

This is where molecular genetics steps in. So-called *reverse* genetics introduces specific mutations at specific sites of the genome. Applied to the behavior of fruitflies, this research strategy makes possible the identification of allelic variants that are strongly associated with behavioral variations. Although such manipulation of human genes is not possible, retrospective identification, through linkage analysis, of loci associated with a phenotypic trait is possible. Here the strategy is to find genetic markers—alleles with a high degree of variability. If variant alleles (markers) match variants in a behavior, the inference is that a gene in the vicinity of (linked to) the marker is involved in the behavior in question. Molecular studies can, in principle, identify genes or alleles whose presence in the genome plays a major causal role in the expression of a phenotypic trait.[27] The markers, of course, are not the genes themselves, and more refined work is required to identify the particular sequence rather than the region of the chromosome where the sequence is located.

One hypothesis was suggested by the earlier mentioned study of a Dutch family, a large percentage of whose male members had high levels of aggressive behavior. The common pedigree prompted a genetic investigation, which showed that they shared a genetically based deficiency in monoamine oxidase A. Alternative hypotheses would concern the possibility that the common behavior was independent of the shared MAOA deficiency. The finding suggested that MAOA deficiency might be implicated in some cases of aggression, but since the deficiency is not nearly as widely distributed as aggressive behavior, no general hypotheses about the etiology of aggressive behavior are suggested.

Social-Environmental Approaches

The social-environmental approaches use measures of aggression similar to those used by the behavior geneticists, except that some studies treat a continuum of social behaviors from the antisocial to the pro-social, rather than limiting themselves to the antisocial. The pro-social (or "sociability") behaviors include offers of assistance, participating in cordial verbal exchange, and display or exchange of affectionate gestures. Aggression is measured by physical (hitting and starting fights) and verbal behavior (angry, hostile speech) as

ascertained by self- and other-reports; delinquency as ascertained in court records; psychological classifications such as antisocial personality disorder and childhood conduct disorder, as ascertained through psychiatric diagnosis; or hostile, confrontational interactions ascertained through direct observation.

The social-environmental approaches in psychology seek to associate distributions of one or another of these measures of aggression with variation in some environmental factor, such as parental behavior, educational experience, or peer relations. Most of the studies using questionnaires or interviews report using more than one measurement strategy (both self-report and other-report, or both self-report and court records) to enhance the reliability of behavioral ascriptions. The methods employed are both retrospective and prospective. Retrospective methods are employed with populations whose relevant parameters are determined via interview and questionnaire, or via direct observation. Prospective methods involve introducing some change into some portion of the target population and determining its effect. Whereas controls in the retrospective studies are populations of individuals who do not exhibit the behavior under study, controls in prospective studies are individuals who exhibit the behavior under study, but who have not experienced the intervention in question.

What these studies can show is the relative strength of a particular social or environmental factor in comparison with others in the same general setting. They tend to assume either uniformity or random variation of genetic or other individually internal factors (such as hormonal or neurotransmitter secretion patterns) and thus measure the relative strength of the various kinds of social factor—parental interaction, parental discipline, parental attitude and behavior toward other family members, peer support, school environment—in producing a particular behavior. Typical hypotheses studied, then, would be (a) from retrospective studies ("Parents who were themselves abused as children are more likely to engage in emotional or physical abuse of their children") or (b) from prospective studies ("Coaching parents to adopt communicative style C in situations S reduces the frequency of aggressive responses from children"). Contrastive hypotheses would concern alternative potential environmental factors. Since the influence of any such factor may vary, given variation in other environmental factors, and since the magnitude of their population level effects may vary as and if genomic distributions vary from population to population, their conclusions are as limited in generalizability as the conclusions of classical and molecular genetics.

Developmental Systems

Developmental systems researchers have concentrated their empirical work on animal models and on human infants and children. Consequently, they have less

to produce by way of empirical results about behavioral dispositions manifest in adulthood or late adolescence. Nevertheless, individual researchers claim that this approach is the appropriate one to adopt, either for human behavior generally or for some specific behavior.[28] There is, then, no issue yet about defining or measuring behaviors. Given the holism that characterizes this approach, it is not clear how detachable or separable from the functioning of the entire human organism specific behaviors (such as "starts fights without provocation," "hits without provocation," etc.) would be, or what strategies researchers would use to individuate and measure behaviors. In animals, by contrast, various behaviors amenable to experimental intervention have been studied. The main form of argumentation, however, seems to be either conceptual or addressed to the shortcomings of other approaches and re-analyses of their data.

The experimental methods involve intervening in a developmental system to show that a given factor is (contrary to what might be expected from the perspective of another approach) essential to normal development of a trait or behavior. The exception here is Esther Thelen and her colleagues, who, in their research on human infants, systematically vary all features that are involved in a particular kind of performance, if they can ethically be altered. These fine-grained studies of very basic elements of behavioral repertoire both support the general thesis of complex interaction and suggest how much more difficult it will be to study higher-level behaviors by taking the same approach. A hypothesis regarding such higher-level behaviors would emphasize the involvement and mutual modification of genetic, physiological, and environmental factors in the fixation of particular behavioral dispositions, and alternatives might identify different particular (sets of) elements from these categories or the roles of different developmental stages.

One point emphasized by these writers is the distinctness of their concept of a reaction-norm from the behavior genetic concept of a reaction range. The reaction range idea is implied in certain behavior genetic articulations of the genotype–environment interaction. Some behavior geneticists have described this as the genotype setting upper and lower bounds on the expression of a trait across a range of environments. The reaction-norm idea, instead, is that each genotype is "associated with a characteristic pattern of phenotypic changes in response to alterations in the environment . . . [but] the rank order of individuals [regarding degree of expression of a trait] can change appreciably and uncontrollably under novel conditions."[29] The point here is that while across the variation in an environmental component in one setting a given genotype will characteristically be distributed into one order or ranking from lowest to highest expression, in another environment this order will not necessarily be preserved.[30]

Conversely, although one might be tempted to rank environments along degrees of nutritiveness or nurturance, for example, the genotypes will not

respond as though to a continuum of reinforcement, but may instead be differentially activated by the different environments. Instead of *all* allelic variants increasing (or decreasing) in the intensity of expression of a trait when exposed to varied environments, some may and some may not. The implications are equally dire for behavior geneticists as for social-environmentalists, since neither genes nor environment can be thought of as acting independently. There can be no question of partitioning out the separate effects of genetic difference or of environmental differences on the expression of an individual phenotype. Thus the inference from heritability of a given measure of aggression in a population in a given environment (or set of environments) to genetic causality is as problematic as inferring from results in one setting that improving parenting skills will, in general, diminish the likelihood of delinquency in offspring.

Neurobiology

Many of the neurobiological studies on aggression have worked with human populations already clinically identified as antisocial. However, when studying the behavioral effects of psychoactive agents, they also use categories of physical or verbal aggressiveness similar to those employed by the other approaches. In the case of sexual orientation, self-report or Kinsey measures based on questionnaire or interview responses are used. The study methods employed are retrospective, concurrent, and prospective. Retrospective methods include the use of autopsies to identify neurostructural correlates of behavioral patterns attributed to the individual, and correlational studies of prison and hospital records to identify associations between brain injuries or other trauma (e.g., birth complications) and later criminal behavior. Here a typical hypothesis would be, "Damage to region R of subcortical area S increases the frequency of aggressive episodes in patients characterized by conditions C." The contrast would be between absence of damage to R or damage to other regions.

Concurrent methods include brain imaging to identify areas of brain activity related to certain thoughts or sensory stimuli, as well as measuring changes in other physical parameters (heart rate) on exposure to certain cognitive or sensory stimuli. Here a typical hypothesis might be, "Aggressive behavior is causally influenced by increased activity in region R of the neocortex." Contrasting hypotheses would concern lack of activity in region R, or activity in other regions of the neocortex, or the absence of effects of activity in R.

Prospective methods include animal experimentation to identify the effects on behavior of organizational or activational exposure to bio- and psychoactive substances, and clinical trials in humans to ascertain the physiological, psychological, and behavioral effects of neuroactive substances. Here a typical hypothesis would be, "Administration of fluoxetine to clients previously diagnosed with antisocial personality disorder does not increase the frequency of physically

aggressive episodes." Contrasting hypotheses would concern administration of fluoxetine to individuals not so diagnosed, or the behavior of individuals classified as ASP who do not receive fluoxetine, or comparisons of the effects of fluoxetine with those of some other neuropharmaceutical.

Although the retrospective or the concurrent methods can answer questions about the strength of the correlation of a given neural structure or process or type of damage with a given behavior, none can as yet produce data that definitively establishes proof that one kind of neural structure or process causally affects some behavior. While relevant to establishing causal claims, the correlations alone neither establish the direction of causality nor rule out a common cause. The prospective methods do establish that a given factor plays a causal role in diminishing, enhancing, or otherwise affecting a given behavior, but the knowledge thereby gained is still quite crude. The mechanism of action needs to be identified by other methods, and the effects of psychopharmaceuticals are generally quite a bit broader than the intended one.

Discussion

Generating evidentially relevant data in any of these approaches requires, as in all sciences, skill and ingenuity. As each approach gains in sophistication, its experimental and observational methodologies enable it to address more fine-grained questions about the relative impact of the types of factor it studies. In spite of the attention still given to the nature–nurture question,[3] these increasingly sophisticated methods are not designed to discriminate between the approaches. The question, "Do genes or social factors play the greater role in human aggression?" is just too crude to be addressed by the available methods of observation and calculation. Proponents of the different approaches, of course, agree in principle, because they acknowledge that both are involved. Still, they hold out the hope that there is an unequivocal answer to the question about the relative contributions of different factors. To date, however, the structures of investigation preclude acquiring evidence that is relevant to this question. The kinds of data generated by the approaches provide evidence relevant to discriminating between hypotheses internal to the approaches, but not to discriminating between hypotheses from different approaches.

In spite of the fact that they do not have the resources to show that one among them is correct in comparison to the others, the critical interactions that take place among their proponents do have consequences for the understanding of behavior. One consequence is that investigative resources proper to each approach are sharpened as a response to challenge and criticism. A second is that the limitations of each approach are made evident by the articulation of questions that they are not designed to answer. These critical interactions, therefore, enable the refinement of methodologies, the clarification of concepts,

and the design of experiments and studies to control for causal factors demonstrated by others. All this makes for more knowledge, which, judged by means of the evaluative tools available within each perspective, is also *better* knowledge.

Whether the knowledge is good knowledge or knowledge worth having in any more general context depends on assessment at a different level. One approach will probably help elucidate some of the genetic and biological mechanisms underlying behavior, may show the limits of environmental influence and of social interventions in certain settings, or may lead to new genetic technologies. Another will help sort out which kinds of social-environmental factors, if any, predominate over others in the development of particular behaviors, and which social-environmental interventions are effective in increasing or decreasing the frequencies of behavioral outcomes.

Another approach will contribute to the articulation of the complexity of developmental interactions and will possibly contribute to the articulation of guidelines regarding intervention strategies. Another will contribute to understanding the role of specific neural structures and processes in particular behaviors, as well as to the identification of pharmaceutical or surgical interventions that will increase or decrease, enhance or diminish, certain behaviors. Which goal will be emphasized at any given time will depend on (1) the relevance and connections that can be made to other research programs; (2) the relevance that can be established to social interests; and (3) the priority given to certain cognitive and social aims over others.

Contrary to most of those who argue on behalf of one or another of the approaches, these matters are not just questions of which approach is empirically correct, or even more likely to produce results. They concern the *kind* of knowledge we seek to acquire, and they must be settled by appeal to different standards than are involved in evaluations of the adequacy of the content of models and hypotheses to their intended object. Advocates of the different approaches must make a case for the value of the kind of knowledge their approach is capable of providing. But this involves quite different skills than those involved in the design of experiments and the evidential testing of hypotheses.

NOTES

1. Because research on the etiology of behavior is always research about some particular (category of) behavior, it's necessary when engaging in comparative analysis to pick one or two behaviors in order to track similarities and differences across a consistent base. For reasons unrelated to this chapter, I have focused on research on two kinds of behavior—aggression and sexual behavior—reviewing the kinds of empirical studies being done and then looking at the theoretical and polemical writing to provide a guide to their broader intellectual contexts. Thus, examples of research that I cite here are drawn from this material.

2. Burgess and Molenaar (1993).

3. See Longino (2001) for discussion of the variety of dimensions of such behavior.

4. Mason and Frick (1994).

5. Brunner et al. (1993). Five members of the family exhibited extreme levels of violence, whereas nine others exhibited more moderate, but still higher levels of violence.

6. Hamer et al. (1993).

7. McGue (1994); Scarr (1992, 1993); Plomin, Owen, and McGuffin (1994).

8. A recent paper (Anderson and Bushman, 2002) identifies five different theoretical orientations falling under this general designation.

9. Lavigueur, Tremblay, and Saucier (1995).

10. Adam (1996). For other anthropological work, see Ortner and Whitehead (1981) and Herdt and Stoller (1990).

11. Haapasalo and Tremblay (1994).

12. Bierman and Smoot (1991).

13. Baumrind (1993).

14. Gottlieb (1991). Susan Oyama is one of the principal theorists and spokespersons for the developmental systems approach. See Oyama (1985, 2000).

15. Eldredge and Grene (1992).

16. See Thelen (2000) and Thelen and Smith (1994).

17. Lerner (1991).

18. Cf. Johnson (1993); Edelman, Gall, and Cowan (1984).

19. Ferris (1993, 1994).

20. For an early study see Biegon, Segal, and Samuel (1979).

21. Coccaro, Gabriel, and Siever (1990).

22. Similar issues to those studied by Rasmussen (1995) in the development of electron microscopy will undoubtedly arise with the future development of the various visualizing technologies.

23. Raine et al. (1994).

24. LeVay (1991).

25. For example, some studies such as Heiligenstein et al. (1992) received funding from the Eli Lilly pharmaceutical company.

26. For a preliminary discussion of problems in the definition of behaviors, see Longino (2001, 2002).

27. For a good discussion of what genes can be said to cause or determine, and how, see Waters (2000).

28. Byne and Parsons (1993).

29. Wahlsten and Gottlieb (1997), p. 172.

30. While behavior geneticists don't observe this refinement in practice, it is not clear that the reaction range concept is not capable of this subtlety. See Turkheimer, Goldsmith, and Gottesman (1995). As reaction-norm and reaction range are used, they highlight different aspects of the complex gene–environment relationship.

31. See, for example, the discussion sparked by recent books by Pinker (2002) and Riddley (2003).

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13

Introspective Evidence in Psychology

Gary Hatfield

Introspection was once the mainstay of psychological research, the primary source of psychological evidence. But, as history has it (e.g., Lyons, 1986, chs. 1–2), in the first part of the twentieth century introspection was discredited by behaviorists in psychology, and by the likes of Wittgenstein and Ryle in philosophy. These critics purportedly showed that introspection was unscientific, conceptually impossible, or akin to believing in ghosts. As a result, introspection disappeared as a source of evidence in psychology and philosophy alike (Lyons, 1986).

This standard account, as most do, contains a grain of truth. Introspection, broadly conceived, was once the primary source of evidence in experimental psychology—although it was never, in any period of psychology's long past, considered to be the only source of evidence (Hatfield, 2003b; Titchener, 1912a). Even as one among several sources of evidence, introspection was in decline by the middle of the twentieth century, both in philosophy and psychology, largely because of attack from the behaviorists. Although the use of introspective evidence was not fully abandoned, criticisms from within psychology put an end to *analytical introspection*, narrowly defined to mean a specific method of seeking the "atomic" elements of experience.

Interest in introspection has recently revived, in two contexts. In connection with questions about first-person knowledge, some authors have offered positive accounts of self-knowledge of some mental states, especially opinions and convictions (e.g., Moran, 2001). In connection