Book Review

Nature/Nurture: Integration through Constructivism?

Liars, Lovers and Heroes: What the New Brain Science Reveals About How We Become Who We Are, by S. Quartz & T. J. Sejnowski (2002). New York: HarperCollins $23.95. 336 pp.

The question addressed by Quartz and Sejnowski in this book is how the brain develops the neural organization that allows complex behavioral capabilities, including those identified as properties of mind. In contrast to more deterministic viewpoints holding either that there are genetic "blueprints" for precisely designed brain modules (evolutionary psychology) or that human behavior is entirely reflective of culture (cultural relativism), Quartz and Sejnowski approach the question from the theoretical perspective of neural constructivism. Here, the emphasis is on the flexibility of the developmental process, a flexibility that is inherently constituted by the system comprised of genes in interaction with their environment. They propose that this is the way in which human culture helps to build the precise circuitry of the brain that enables the construction of symbolic models of the world. The following review will provide an overview of the ideas presented in the book, concluding with a discussion of the issues seen to be of particular interest to developmental psychobiologists.

An integral theme of the book is how evolutionary theory, including the so-called modern synthesis, has been used to support various ideological positions with respect to the role of biology in human affairs. Inherent to Darwinian thought is the notion of progress based on the struggle among individuals, and the transmission of individual traits that confer reproductive advantage. The modern synthesis challenges these ideas on two fronts. First, as historical events have conspired to undermine the notion of human progress, so too has evolution come to abandon the concept of an overall plan in favor of random contingencies. Second, the identification of the genetic code and the subsequent investment of resources in the Human Genome Project have resulted in a shift in emphasis away from the individual towards the gene as the unit of selection, where the competition for survival into the next generation is seen to be among "selfish genes" rather than among individuals. There has been considerable fluctuation in opinion during the 20th century on the relative importance of biology to human behavior. Following the dismissal of Social Darwinism at the turn of the century, empiricist theories emphasizing the role of experience and culture gained ascendancy. In contrast, work on animal behavior, and in particular the studies conducted by ethologists, continued to be informed by a biological perspective. This work advanced the understanding of ecological adaptations, thereby providing a framework for the theory of Sociobiology. According to this theory, behaviors (including those of humans) are seen as precise adaptations to a species-typical ecological niche, recognizing that the nature of the social interactions within a species contributes to the defining attributes of such a niche. Both altruistic and aggressive behaviors are viewed as innate responses that are elicited by specific social contexts. There has been strong reaction to these ideas by many people who associate them with infamous eugenic policies of the 20th century. They have nonetheless been influential in the subsequent development of the thinking now characterized as Evolutionary Psychology. In contrast to Sociobiology's view that human nature represents an adaptation to modern life, Evolutionary Psychology views brain and behavior as adaptations to an ancestral environment. The brain is seen as a collection of specialized modules that have served us well in the past ("Swiss Army Knife"), but which may contribute to our being misfits in the modern world. Furthermore, oversimplistic reports by the popular media (and sometimes by the scientific community) of finding "the gene for" various ailments that plague humankind have fueled public imagination with respect to overriding importance of the gene in specifying the nature of these hypothetical modules. This has in turn led some to postulate that it may be possible to change various socially aberrant behaviors merely by altering genes.

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Neural constructivism presents a very different viewpoint. There is essential agreement among contemporary models of brain development on the necessary role of either intrinsically or extrinsically generated neural activity; however, these models differ with respect to their conceptualization of the nature of the exact contributions of genes and environment to the development of specific brain systems. The nativist model posits detailed prespecification of domain-specific modules by the genes, with the role of the environment being that of merely enabling the developmental process or of acting as a trigger. Here, the development of cortical specialization is seen to occur through selection, whereby intrinsic construction (''prerepresentation'') is followed by the survival of functionally meaningful connections through selection resulting from experience. The empiricist model, on the other hand, focuses on environmental events as the main source of input in structuring the specialized functional domains of the cortex. Both these models, through their conception of biology and environment as independent contributors to the developmental process, espouse a view of each that is essentially static. Neural constructivism, in contrast, is far more radical. It differs from both the strictly nativist and empirical approaches through its emphasis on the interdependence of biological structure and environment. It postulates that structure derives ultimately from ongoing dynamic interactions between the mechanisms of neural growth and environmentally derived neural activity. It does not deny innate constraints, but these are seen to be at fundamental biological levels related to basic cellular and molecular processes. The structure of the world also is seen to contain essential information, thereby making it unnecessary for all the information essential to development to be encoded in the genes. Moreover, inputs from the environment, rather than being independent, are seen as constantly changing as a function of the organism's stage of development.

According to this view, development is characterized as an incremental increase in representational complexity, but this is a complexity that is created by the developmental process itself rather than unfolding according to a predetermined plan. In addition, there is a shift in emphasis from the central importance of genes, per se, to the factors that influence gene expression. Such factors include not only the immediate cellular and internal physiological environment, but also sensory input from the external environment, including that provided by social interactions. By influencing how, when, and for how long genes are active, developmental variations associated with these factors can lead to very different phenotypic outcomes. Furthermore, because of the flexible and dynamic interdependence of genes and environment, a variety of developmental outcomes may be affected by small changes in input. Thus, rather than being viewed merely as means to a predetermined end, developmental mechanisms are seen as central in creating the phenotypic variability on which selection ultimately acts.

Quartz and Sejnowski use this neuroconstructivist conceptualization of development to build a theory of individual differences that they term ''Cultural Biology,'' where biology is seen as central to the flexibility of the brain. Contrary to the notion of an ancestral environment, they propose that human evolution took place under rapidly fluctuating environmental conditions. In a world that is always changing, the main function of the brain is seen to be that of serving as a database of past events and in using that knowledge to predict the future. Of central importance under such conditions are the mechanisms in the brain that allow engagement with the world and the ability to learn from this experience to support adaptive decision making in the future. These functions involve complex interactions between cortical and subcortical structures, including striatum and prefrontal cortex; these brain regions mature at different rates, such that during the course of human development, behavioral control shifts from subcortical systems to the relatively late-maturing prefrontal brain structures. It is postulated that the early maturing systems preferentially motivate and guide interactions with the world, and the outcome of these experiences then contributes to the development of the circuitry of the later maturing structures. It is important to keep in mind the fact that these cognitive mechanisms do not act in isolation but are intertwined with those that mediate emotional and motivational value. For example, humans always experience the world within a social context, initially that of the parents and later extending to the broader society. The nature of this social experience is powerfully reinforcing, so that systems involved in emotional and prosocial development enable learning about the contingencies of the social world. This social world includes the complex symbolic systems whereby humans organize and give meaning to their worlds. It is through this function of assigning relative values to different experiences that human culture may help to build the precise circuitry of the prefrontal cortex which enables the construction of models of self and others.

The subcortical system that is identified as integral to these processes by serving as an ''internal compass'' is the mesocorticolimbic dopamine system. There are two midbrain dopamine systems: the nigrostriatal system and the mesocorticolimbic system. The nigrostriatal system originates in the substantia nigra and projects to the basal ganglia where it is involved in behavioral activation. The mesocorticolimbic system originates in the ventral tegmental area and projects to the nucleus accumbens as well as to various other subcortical and cortical structures including amygdala, hippocampus, and

prefrontal cortex. The functions served by this system in interaction with these other structures include emotion, motivation, and response to reward. The role of dopamine in the nucleus accumbens, rather than mediating the hedonic response as was thought previously, has been identified as that of labeling environmental stimuli with incentive value. In this way, it facilitates the initiation of the appropriate instrumental response; in other words, it acts to ''energize'' active engagement with the world. It also serves an important teaching function by monitoring unpredictability and indicating when rewards deviate from expectation. In addition, it facilitates the interactions between the prefrontal cortex and nucleus accumbens that enable the use of previous cognitive and emotional experience to inform the choice of the appropriate behavioral response in a new situation. As mentioned earlier, potent reinforcers of behavior during the process of mammalian development are those that include social cues. In fact, social attachment is considered a precondition in humans to allow for the protracted development of the relatively larger human brain. As with other reinforcers, the response to social reinforcers is mediated through the motivational and information-processing effects of the dopamine system. Moreover, consistent with their role in mediating other types of hedonic response, endogenous peptides also are thought to play an important role in the affiliative response as well as the pituitary hormones oxytocin and arginine vasopressin. As might be expected, these systems do not function in isolation but interact extensively with other neuromodulatory systems, most notably norepinephrine and serotonin. It is therefore not surprising that they have been implicated in a variety of pathological conditions, most notably drug addiction as well as schizophrenia, depression, mania, and obsessive compulsive disorder.

Although the idea that protracted human development allows enculturation through learning is not new, what makes cultural biology different from the empiricist position is its emphasis on the role of biology in making the developing organism an active participant in the process. The thorny question of origins of individual differences in behavior is addressed in the context of the distinction often made by personality theorists between the constructs of temperament and personality. Temperament is described as an inherent predisposition to interact with the environment in ways that fall along particular emotional dimensions, such as novelty seeking, harm avoidance, and reward dependence, which can be modified by experience. Interestingly, these are the functions most usually associated with the mesocorticolimbic dopamine system. Personality, on the other hand, is seen to be more open ended, depending on the capacities of the prefrontal cortex. These capacities have developed in response to the experience gained from interactions with the environment. The nature of these interactions may be biased initially by temperament, but over time it is possible for these temperamentally based predispositions to be modified by experience. In humans, such experience includes the worlds of symbolic meaning constructed collectively as member of a society, where culture can be thought of as a ''cognitive web.'' It is postulated that beliefs, because of the intensity of the emotional value attached to them by the culture, can, through the course of development, become ideologies. As such, they have a pervasive influence on decision making and are strongly defended against other competitive belief systems. In the final pages of the book, the authors reflect on the implications of these ideas with respect to the ideological warfare that has characterized human history—including, in a provocative afterword, those related most recently to events involving global terrorism.

As is clearly evident from this brief synopsis, the questions addressed in this book are of central concern to developmental psychobiologists. They also are those to which this field has made important empirical and theoretical contributions over the last quarter century; in fact, much of the source material on which the authors draw derives from studies in the literature with which many members of this society will be familiar. For those interested in reading further, an informative perspective on the development of neuroconstructivist ideas can be found in a current anthology of readings on brain development and cognition (Johnson, Munakata, & Gilmore, 2002). Of particular interest as to how this perspective might inform the formulation of questions in developmental research is the emphasis on the developmental process itself in the study of developmental disorders (Karmiloff-Smith, 1998). Atypical language development, for example, rather than being the result of a mutation in a ''language gene'' might derive from a mutation that affects the sensitivity of auditory processing, thereby distorting auditory input and its subsequent influence on the organization of auditory cortex (Karmiloff-Smith, Scerif, & Thomas, 2002). In the same vein, it has been suggested that attempts to understand the risk factors for attention deficit hyperactivity disorder (ADHD) might be more successful if they moved away from atheoretical clinical descriptions to intermediate constructs known as endophenotypes (Castellanos & Tannock, 2002). Endophenotypes are defined as heritable traits that are associated with the development of a given condition, and are thought to be more directly implicated in the actual mechanisms than dichotomous diagnostic categories. In ADHD, for example, the proposed defect involves a specific abnormality in reward-related dopamine circuitry that would lead to a constellation of testable hypotheses involving patterns of response to reward, delay gradients, temporal processing, and working

memory. Interestingly, a recent review on work done in rodents in relation to ADHD focuses on the critical role of early developmental events in the modulation of prefrontal function by the mesocortical dopamine system (Sullivan & Brake, 2003). This review describes a variety of developmental insults that affect prefrontal regulation including not only biological risk factors such as hypoxia during the pre- or perinatal periods but also disturbed caretaker–infant interactions. Thus, in support of the thesis advanced by Quartz and Sejnowski, the authors of this review state that ''such findings highlight the importance of not only prenatal conditions, but the postnatal social environment in the optimal maturation of these critical prefrontal and associated circuits'' (p. 47).

In contrast to their own more specialized writings on the topic (Quartz, 1999; Quartz & Sejnowski, 1997), it is important to emphasize that the book under review is aimed rather at the general public. It is in fact the kind of book one might recommend to one's relatives and friends who are interested in understanding why the biological mechanisms underlying brain and behavioral development might be interesting and important. It is very ambitious in scope, ranging broadly over many disciplines including not only Psychology and Neuroscience, but also Anthropology, Computer Science, Economics, Ethics, Molecular Biology, Philosophy, Political Science, and Sociology. In so doing, it faces the challenge of communicating a broad range of highly technical information to a largely nontechnical audience in a readable fashion while also conveying the excitement of the ''big picture.'' It succeeds admirably in this respect. Those working in the field might quibble at times with respect to oversimplification of what are admittedly complex issues and the use of ''catchy'' phrases such as the brain's ''chemical soup'' and ''user's guide to life.'' But these can be seen as minor irritations in the context of the strengths of the potential contribution to be made by a book such as this to public discourse on the relationship between brain and behavior. It serves as a welcome addition to this debate by directing the spotlight on developmental processes rather than on outcomes, and by its claim that the adaptive capabilities of the brain are constituted by biology interacting as an equal partner with the environment not only during development but possibly throughout the life span.

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