Causal Analysis in Modern Developmental Psychobiology: Important Lessons for Behavior Analysis

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Kuo's radical ideas about instinct, evolution, and development reveal a set of conceptual arguments and, especially, recommendations for causal analysis that are highly compatible with those held by behavior analysts in the tradition of B.F. Skinner. It is proposed that if behavior analysis is to take on a full examination of development, we will need a model for ontogeny that prompts us to uncover the mechanisms by which individuals come to display characteristics typical of their species; the mechanisms of the epigenesis of behavior. Broadly conceived, this is the task of a truly causal developmental analysis.

When John B. Watson and other early behaviorists proposed the foundation for a scientific account of human and animal activities, they did so by addressing the most pressing methodological and philosophical issues of their time: Namely, (a) reliance on introspection as a primary methodology, and (b) the notion that the mind is the source of adaptive activity and is equipped, through evolution, to direct pre-adapted emotions, thoughts, and performances (e.g., Guthrie, 1930; Watson, 1930). These early behaviorists spawned a revolution in American psychology by defining the methods and the subject matter of our science. They also challenged the prevailing notion that virtually every complex adaptive activity could be tidily attributed to an inborn instinct (Hilgard & Bower, 1966, pp 75-76).

Kuo's Ideas on the Causes of Development

Zing-Yang Kuo was a young contemporary of Watson's who was sympathetic to the aims of the early learning theorists in developing an objective, experimental, and especially "investigative" science. However, he felt that the field would not be relieved of the sticky nature-nuture problem by simply demonstrating the role of conditioning or learning in behavioral development. In fact, although he was closely identified with environmentalism, Kuo was equally critical of the nativist ethologists and of learning theorists for their approaches to understanding species specific performance (Kuo, 1967; 1970).

An examination of Kuo's radical ideas about instinct, evolution, and development reveals a set of conceptual arguments and, especially, recommendations for causal analysis that are highly compatible with those held by behavior analysts in the tradition of B.F. Skinner (e.g., Skinner 1966; 1969; 1974; 1975a). Despite this compatibility, historically behavior analysis has not included a model of individual development and evolution that incorporates the thinking of Kuo or his intellectual descendants.

My purpose is to review some of that thinking, paying particular attention to ideas about good and poor explanations for behavioral development. I will follow a few of my colleagues in behavior analysis, especially Bryan Midgley and Ed Morris at the University of Kansas-Lawrence, in suggesting that the developmental psychobiology tradition has generated systems for thinking about the causes of development that resonate with the fundamental tenets of behavior analysis (Midgley & Morris, 1992; Midgley, 1997). If behavior analysis is to take on a full examination of development, we will need such a model for ontogeny: One that prompts us to uncover the mechanisms by which individuals come to display characteristics typical of their species; the mechanisms of the epigenesis of behavior. Broadly conceived, this is the task of a truly causal developmental analysis.

In 1921, when he was still an undergraduate student, Zing-Yang Kuo published an article titled "Giving up Instincts in Psychology" and thereafter stood out as an insightful and challenging participant in the nature-nurture debate (Kuo, 1921; see Gottlieb, 1976 for a brief biography of Kuo). In his last publication, in 1970, he said:

> The chief objective of the epigenetic behaviorist is to seek order out of [such] complex behavioral phenomena in order to formulate laws of behavior without resorting to vitalism either implicitly or explicitly. (Kuo, 1970, p 25)

Kuo was concerned with combating the same types of non-explanation that bothered Watson, and later Skinner, particularly concepts that were substitutes for true causal analysis. It is this core argument about the nature of adequate explanations for behavior that will be most familiar to behavior analysts. For example, Kuo argued that the more we learned about the causes of behavioral

development, the less we would rely on mental concepts and other empty explanations (Kuo, 1970; p. 4): "To call an acquired trend of action an instinct is simply to confess our ignorance of the history of its development." (Kuo, 1921, p. 650)

Another aspect of Kuo's arguments about explanation that will sound familiar to behavior analysts is his preference for those that lead to investigation--and especially to manipulable variables (Gottlieb, 1976, p. xiii). Kuo conducted a series of studies in which he attempted to change typical developmental outcomes (such as aggression of cats towards rats) by systematically varying rearing conditions (Kuo, 1970, p.63-65). His approach to causal analysis was to vary specific environmental events in ontogeny in order to look for related variations in behavioral development--he attempted to predict and control the behavioral outcomes of development. Kuo assailed the concept of instinct especially for directing attention away from this kind of analysis of causal events occurring during individual development:

> [Kuo's] attack was based on the insight that the use of instinct as an explanatory concept was harmful to a genuine understanding of behavior because it made the analysis of development superfluous, and therefore, unnecessary. (Gottlieb, 1976, p xiii)

In other words, when a response in question is attributed to instinct, and therefore to the evolution of the species, questions about the mechanisms by which it arises during an individual's development are circumvented. Kuo said that any explanation for the presence of behavior which ignored the ontogeny of that behavior in the individual was no explanation at all (Kuo, 1970):

> To assume any inborn tendency is to assume an *a priori* relation between the organism and stimulating objects; for every behavior is an interaction between the organism and its surrounding objects. Such an assumption is no less objectionable than the theory of innate ideas. (Kuo, 1921, p 650).

For developmental psychobiologists, then, the appearance of a match between the behavior of the organism and its environment (in the absence of so-called relevant experience) demands a causal analysis of the events responsible for that behavior appearing in the individual. They refuse to simply celebrate the actions of a fortuitous genetic and neural endowment, but instead set out to uncover the structural and experiential history of the organism that precedes the appearance of an adaptive response. It is useful to note that the same argument is made for the development of the morphology of the organism (through embryogenesis).

This is a radical departure from an approach in which the appearance of an adaptive response in the absence of obviously relevant experience is credited to the genetic endowment of the organism, or as in behavior analysis, to the selection contingencies for the species that determine that endowment (Midgley & Morris, in press). For example, chicks begin pecking at small objects very shortly after hatching, obviously having had no similar experiences inside the egg. The traditional developmentalist, and behavior analyst, once satisfied that pecking does arise in the absence of extra-egg environmental input, both attribute the performance to maturation of the nervous system and other related morphology, a largely passive process of growth directed by the genes in which the stimulating environment plays no important part.

> As far as innate behavior goes, then, in this view the genes provide an essential controlling or determinative impetus to the development of the nervous system, including peripheral sense organs and muscles. In a word, genes are thought to somehow be at the base of neural maturation, which in turn leads to the manifestation of innate behavior. (Gottlieb, 1976c., p. 239)

In contrast, Kuo and others adopted the conceptual stance that a full explanation of the development of a response requires an analysis of the local causes of development, including reference to the morphology and physiology of the organism as well as current physiological and environmental events (such as hormonal states and eliciting stimuli). Kuo himself is well known for having developed techniques for removing the top of chicken's eggs late in their development in order to view and record behavioral, neuromuscular, and stimulative events occurring before hatching. In the case of pecking, for instance, the head rests directly on top of the heart late in embryogenesis. If the chick's head is displaced in such a way that it does not receive the "typical" rhythmic stimulative experiences from resting on the heart, lunging and pecking shortly after hatching are affected:

> Kuo believed it was useful to regard all behavior as being acquired during individual development--in this way, one is forced to come to grips with an analysis of the anatomico-physiological maturational events, as well as the environmental contingencies, which determine behavior. From an ontogenetic viewpoint, all behavior has to be "acquired" during development-unless, that is, one cares to make a case for preformation. (Gottlieb, 1976, xv.)

Kuo's studies of prenatal development of chicks is instructive in another way. Notice that in this example, the prenatal "experience" that is thought to play a causal role in the appearance of pecking is self-stimulative, not dependent on the extra-egg environment. And that self-stimulaton is largely a consequence of the structural features of the organism such as the heart, the way the head and neck are positioned at this point in development, etc. Developmental psychobiologists have been particularly concerned with the role of self-produced stimulation in their causal models. In their formulations, it has been important to distinguish between behavior that appears to be completely autogenous from that which has identifiable experiential causes, even if some of those causes are contained within the skin of the organism and arise as a direct result of organismic structures (structures which, not incidentally, have their own analyzable developmental histories).

Other Metatheoretical Conceptions by Developmental Psychobiologists

Much of this conceptual concern about the role of self-produced stimulation arose in the field of experimental embryology--which clearly overlaps with the study of early behavior and the development of the sensory systems. In the late 1800's, science had only recently rejected the idea that the entire structure of the individual was present, albeit in a tiny form, in the fertilized egg. Later studies of the conditions under which the first movements of embryos arise revealed that in some cases, movement or sensory function preceded all afferent input (e.g., Oppenheim, 1963; Hamburger, 1973, Hubel & Weisel, 1963). In other words, some movement and sensory function can be entirely autogenous and not dependent on any extra-organism stimulation.

For developmental psychobiologists, a full causal picture of behavioral development would explain the genesis of both behavior dependent on endogenous stimulation and behavior that is autogenous. The level of biochemical "experience and context" for migrating neurons, for example, is part of a causal description of how behavior develops--although developmental psychobiology generally leaves questions about the chemical and structural determinants of early neural proliferation and migration, for example, to the embryologists. However, they do take a unique view of the role of those autogenous responses and sensory capacities in causing subsequent development. When the organisms own spontaneous movements affect subsequent structural and behavioral development, they become causal experiential variables:

> . . . experience involves sensory or motor function whether evoked or spontaneous. . .spontaneous (as well as evoked) neural activity may play an important role in neural maturation and behavioral development. (Gottlieb, 1976b., p. 27)

If stimulative factors, which operate through the functioning sensory system can be determinants of structural development, then the typical "structure causes function" notion of development is turned around. Now function is seen as causing structure. In fact, acknowledgement and analysis of the bidirectional relationship between structure and function, or structure and behavior is a hallmark of developmental psychobiology (see Oyama, 1985 for a discussion of the structure-function relationship and Midgley & Morris, 1992 for a review of her book from the point of view of behavior analysis).

In this way of thinking, everything about the organism has to be "acquired" or constructed during ontogeny--morphology, physiology and behavior. Structure and behavior, sensory, and motor functioning have a bidirectional causal relationship. When everything about the organism is seen as being acquired, and when the structure of the organism is affected by its own developing functions, it becomes necessary to consider the acquisition of structure and function as probabilistic and influenced by a sequence of environment-organism interactions, not as predetermined and invariant:

> One viewpoint holds that behavioral epigenesis is predetermined by invariant organic factors of growth and differentiation (particularly neural maturation), and the other main viewpoint holds that the sequence and outcome of prenatal behavior is probabilistically determined by the critical operation of various endogenous and exogenous stimulative factors. (Gottlieb, 1970; p. 111)

But what can this kind of reconceptualization of ontogeny and its determinants do for behavior analysis? In the long run, this perspective would allow behavior analysis to adopt a conceptually consistent view of development--one which highlights the "hows" of behavioral development (Anastasi, 1958); just as the existing system of explanation in behavior analysis focusses on the "how's" of behavior maintenance and change (e.g., Skinner, 1966). In this sense it could set the stage for a "downward extension" of the existing explan-

atory concepts in behavior analysis into prenatal or pre-operant models of influence on the organism which are necessary for a thorough and systematic behavior analysis of development.

Admittedly, a full introduction to this perspective and its relationship to behavior analysis requires a considerably more detailed review and exposition than I have presented here. An examination of how behavior analysis and developmental psychobiology view the reciprocal interaction between structure and function in the development of behavior, for example, would certainly be in order (this is one topic I'll defer to a subsequent paper). There are several other steps one might take or "chapters" one might write about this relationship (Midgely & Morris, 1998). For example, I have not introduced the conceptual and empirical work of researchers and writers who have championed and extended the psychobiological perspective (e.g., Lehrman, 1953; Schneirla, 1972; Gottlieb, 1976b, Oyama, 1985; Thelen, 1993), nor the few examples of behavior analytic work that I view as explicitly compatible with it (e.g., Schusterman & Kastak, 1998). I expect that discussions of the relevance of psychobiology and developmental systems to behavior analysis will continue and will generate these and many more such "chapters" to the benefit of behavior analysis.

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