Learning and Growth: Developmental Changes in Behavior

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Any scientific approach to the understanding of developmental change must assume that developmental outcomes are determined by many factors, including: 1) species-specific, biologically-based perceptual and behavioral capacities (prescribed by the morphology of the species), 2) individual biologically-based perceptual and behavioral capacities (prescribed by variability in morphology within the species), 3) maturational growth, 4) a history of interactions with the environment, and 5) current task demands. However, the assumption of determination does not imply the ability to predict outcome or patterns of change for any given instance (Marr, 1996), which suggests significant modifications to current theoretical, methodological, and statistical practices in developmental science. In particular, the utility of an ecological, dynamic systems approach for exploring change will be proposed as appropriate for conceptualizing development.

Developmental outcomes can be described as relatively stable patterns emitted by an individual when the following components come to be organized in new ways: 1) species-specific, biologically-based perceptual and behavioral capacities (prescribed by the morphology of the species), 2) individual biologically-based perceptual and behavioral capacities (prescribed by variability in morphology within the species), 3) maturational growth, 4) a history of interactions with the environment, and 5) current task demands. Any scientific approach to the understanding of developmental change must assume that developmental outcomes are *determined* by these factors. However, the assumption of determination does not imply the ability to predict outcome or patterns of change for any given instance (Marr, 1996), which suggests significant modifications to current theoretical, methodological, and statistical practices in developmental science. In particular, the utility of an ecological, dynamic systems approach for exploring change will be proposed as appropriate for conceptualizing development. In addition, it will be argued that this new metatheory provides an excellent base for integrating behavior analytic and non-behavior analytic developmental approaches. An example of such an integration is the new textbook, "Developmental Psychology: Dynamic Systems and Behavior Analysis," written by Gary Novak (1997). Here, I, a developmental scientist who was not trained formally in behavior analysis, would like to further promote such an integration.

Applying Dynamical Systems Assumptions

A dynamical analysis involves understanding a pattern of changes over time in a particular variable that is well-defined and observable (Thelen & Smith, 1994), and it can be conducted through multiple methods, including various quantitative mathematical and statistical procedures (Barton, 1994). Key conceptual features of dynamic systems theory, however, entail methodological approaches that are more qualitative in nature (Haynes, Blaine, & Meyer, 1995), and hence provide a starting place for thinking in new ways about investigating behavioral development. First, the idea that continuous changes in certain components of a system can lead to sudden state changes provides us with a mechanism for transitions to novel forms (or stages) (Barton, 1994; Rosales-Ruiz & Baer, 1996). This suggests the need for a large number of observations of the system just prior to the time of change and a search for high levels of behavioral variability in the system at the time of change (Siegler, 1996).

Second, dynamical systems are seen as self-organizing in that stable, new structures or patterns emerge in open systems (ones that exchange energy) without necessarily being specified by external, environmental constraints. An example of self-organization comes from the footfall pattern, or gait, of a horse, as increases in the energy being expended toward forward locomotion, result in dramatic changes in the form of the locomotion. These changes are in large part determined by the anatomical structure of the horse which constrain possible outcomes (Thelen, 1995). Dynamical systems therefore involve both stability and flexibility, and are susceptible to restructuring with small perturbations in various aspects of the system. Thus, strategies for examining dynamic systems should entail a focus on the conditions that invoke transitions, and the importance of variability at the local level (i.e., the importance of task demands and performance) are highlighted (Eckerman, 1993; Kelso, 1995; Siegler, 1996; van Geert, 1994).

This perspective has obvious applicability across the natural sciences, and has been guiding theory and research in biology, physics, and chemistry (e.g., see Baskin & Mittenthal, 1992, Gleick, 1987, and Haken, 1983, for reviews). It has also appealed to a number of developmental psychologists (e.g., Eckerman, 1993; Fogel, 1990; Fogel & Thelen, 1991; Smith & Thelen, 1993; Thelen & Smith, 1994), as well as behavior analysts (see the Special Issue on Behavior Dynamics, May 1992, JEAB). Critically, these investigations challenge some aspects of traditional scientific methods. While the perspective is deterministic, because of a focus on the complexity of the interactions of the causal mechanisms (e.g., non-linear, non-additive effects, feedback loops), dynamic systems are extremely sensitive to initial conditions. Even with attention focused on critical historical values of target behaviors and causal factors (Heiby, 1995a; 1995b), prediction and control are difficult, and may be unreasonably stringent criteria for experimental analyses.

Applying a dynamic systems approach means taking changes in performance over time very seriously, a fact which forms the basis for the suggestion that the theory provides an opportunity for greatly expanded discourse between developmental psychology and behavior analysis. Developmental scientists are increasingly focused on the importance of variability to ontogenetic change, and the traditional focus on competence, rather than performance, is being strongly criticized (e.g., Sophian, 1997). In fact, variability in behavior is being stressed as the most critical characteristic of an immature organism to consider when describing development (Siegler, 1996). Variability across organisms and environments is not noise but is the source of data that yields the best descriptions of behavior and development over time, and incorporates the notions of changes in behavioral probabilities, novelty, and fluency (Sidman, 1960; Siegler & Crowley, 1991). That is, in addition to increasing our understanding of the behaviors that are developing, a focus on changes in performance is critical to describing the process by which new behaviors emerge and are maintained.

Variability. Interpreting variability as essential to development entails a discussion of selectionist accounts of behavior change (Baum, 1995). Accounts of change that appeal to age or maturation as an independent variable are problematic as experience is seen as the "true" causal mechanism (Bronfenbrenner & Ceci, 1994; Chi & Ceci, 1987; Cohen & Siegel, 1991; Landau & Gleitman, 1985; Rogoff, 1990). Critical, however, to a perspective that emphasizes experience or history is the notion that stimulus control can not restricted to momentary cause (Rachlin, 1994; Staddon, 1993). An emphasis on contextual variables, or setting events, at all levels is central to the importance of differential experience to developmental outcomes (Baer, 1997; Bijou, 1996; Paniagua, 1997). The consideration of 4- and higher-term contingencies and complex antecedent discriminative stimuli, both historically and currently, is necessary (Pelaez-Nogueras & Gewirtz, 1997). And for the analysis of human behavior, contextual events at the level of culture must also be examined. Cultural learning is being heavily emphasized in both the developmental (e.g., Montgomery, 1997; Tomasello, Kruger, & Ratner, 1993) and behavior analytic literatures (e.g., Glenn, 1991; Lamal, 1991; Malagodi, 1986).

Recognizing the etiologity of reinforcers. A thorough understanding of what is reinforcing to the organism is also critical to selectionist approaches. Mainstream developmental psychology has assumed that human behavior can be maintained by phenomena like perceptual stimulus changes, movement relative to the external environment, the successful manipulation of objects, and proprioceptive feedback. For example, while many developmental psychologists reject the "mentalism" inherent in Piaget's theory of cognitive development, his observations with respect to the enormous amount of independent, variable, manipulative, exploratory "play" behavior in the developing human have been replicated consistently (see Flavell, Miller, & Miller, 1992). These types of reinforcers come under the category of ecological or automatic reinforcers in the behavior analytic literature (Bijou & Baer, 1965; Bijou, 1995; Malcuit & Pomerleau, 1996; Vaughn & Michael, 1982), but have not received very much attention. Developmental scientists have also assumed the strong effects of social stimuli as reinforcers for human infants (Redd, Winston, & Morris, 1977). Current behavior analytic work is systematically manipulating some of these stimuli (e.g., touch, vocalizations, facial expressions, and imitation) (e.g., Gewirtz & Pelaez-Nogueras, 1998; Pelaez-No gueras, Gewirtz, Field, Cigales, Malphurs, Clasky, & Sanchez, 1996) in order to further our understanding of species-typical reinforcers and how they function.

The relevance of physiology and individual differences. A selectionist perspective also implies that while developmental science cannot be reduced to biology (Reese, 1996), physiological products and the neurological substrates of behavior cannot be ignored (Donohoe & Palmer, 1994; Harrison, 1994; Hunziker, Saldana, & Neuringer, 1996; Johnson, 1993; Siegler, 1989). In addition, comparative research (e.g., Sameroff & Suomi, 1996) implies the relevance of both species-specific principles of behavior, and principles that generalize across species, to current developmental science.

Thus, a dynamic systems approach that entails complex change in open systems is being proposed as the best one to account for the key phylogenetic, ontogenetic, and immediate determinants of behavioral development. There will always be the issue of how to conduct experimental analyses involving variables that cannot be manipulated ethically. Developmental psychology has dealt with this through the use of correlational research methodologies, within-subject group designs that capitalize on naturally occurring variability in the multiple determinants of behavior. An illustration follows, one that attempts to place correlational designs within a perspective that incorporates the concepts of both learning and growth: Thompson (1986) proposed that, while "individual variation in emotionality... can shape infants' perceptions of the care-giving environment..." (p. 45), much of the work on early parent-child interaction focused solely on the role of maternal responsivity. However, individual variation in temperament or emotional behavior may interact with the variability observed in parental responsivity or sensitivity. For example, one critical measure of responsivity and sensitivity is latency to attend to infant cries. Individual differences in frequency of crying may have a large influence on how infants learn the contingencies that are operating in this behavioral sequence. Similarly, frequency of gaze aversion on the part of the infant might influence the ability to gain certain kinds of information available in face-to-face interaction with a caregiver through facial expressions and vocalizations. Complicated 4- and higher-ter m contingencies are nowhere more evident than in these interactions and most probably provide the critical environmental setting for skills like imitation.

In addition, variability in infant behavior may have the effect of differential elicitation of caregiver behaviors. Adults are more likely to use reasoning about the consequences of behavior when working on a task with a child with a person orientation (one who looked frequently at the adult's face and was verbally responsive) while being more likely to use power assertion discipline strategies with children low in person orientation (Keller & Bell, 1979; see also Brunk & Henggeler, 1984; Cantor & Gelfand, 1977). Similarly, with children who tended to avoid social contact, in contrast to those who seek out such situations, adults pay less attention, show low physical contact, and interact infrequently (Taylor & Carr, 1992a; 1992b). While these data are correlational, the studies were designed to assess the impact of the child in interactions. Yet another potential child effect is evident in recent findings in the child language literature that suggest adults prefer syllabic vocalizations on the part of a baby (Bloom, D'Odorico, & Beaumont, 1993). That is, these findings show that adults tend to reinforce syllabic vocalizations to a greater degree than they do non-sy llabic vocalizations. Thus, infants who emit more non-syllabic vocalizations may receive less adult attention.

In all of these situations, individual differences in infant characteristics (which are at least partially heritable, as indicated by the growing amount of evidence from the field of behavioral genetics (e.g., Bates & Wachs, 1994, Plomin, 1989; Plomin & Daniels, 1987; Suomi, 1987)) would have the effect of exposing infants to differential amounts and types of information about the social environment. These differences in infant behavior are also likely to be differentially maintained by operant contingencies, thus yielding differential learning. These types of analyses are necessary for identifying the influential determinants inherent in the dynamic system that is the developing human in a species-typical environment (Fogel & Thelen, 1987; Goldfield, 1995).

Conclusion

Developmental psychologists want to describe the process by which behaviors come to appear in the human repertoire that are not observable in the newborn infant. Dynamic systems theory provides a model for conceptualizing the interaction between nature and nurture in producing behavior. It forces us to not just explain organism-behavior causal relations or environment-behavior causal relations, but rather to see behavior as emergent from the organism-environment dynamic system. The model allows us to fully acknowledge species continuities and discontinuities, developmental continuities and discontinuities, and behavioral continuities and discontinuities. Gewirtz and Pelaez-Nogueras (1996) recently defined the study of behavioral development as the study of 1) changes in the complexity of the controlling environment (including the origins of and changes in reinforcers), 2), early experience as containing important determinants of later behavior, and 3) contextual variables and their relation to interactions among stimulus and response functions. My claim here is that much of current research and theory in mainstream developmental is covered by this definition (see Cairns, Elder, & Costello, 1996, for example). If we put together these two branches of research traditions, behavior analysis and developmental psychology, under the guidance of a dynamic systems perspective, I think we might make significant headway on questions concerning developmental change. Paying attention to the key features of the theory is critical, and includes a new meaning for time, a new meaning for variability, and a new respect for individuality (Thelen & Smith, 1993).

References

Baer, D. M. (1997). Some meanings of antecedent and environmental control. In D. M. Baer & E. M. Pinkston (Eds.), *Environment and behavior*. Boulder, CO: Westview Press.

Barton, S. (1994). Chaos, self-organization, and psychology. *American Psychologist, 49*, 5-14.

Baskin, A. B., & Mittenthal, T. E. (1992). *The principles of organization in organisms*. Redwood City, CA: Addison-Wesley.

Bates, J. E., & Wachs, T. D. (Eds.) (1994). *Temperament: Individual differences at the interface of biology and behavior*. Washington, DC: American Psychological Association.

Baum, W.M. (1995). Rules, culture, and fitness. *The Behavior Analyst, 18*, 1-22.

Bijou, S.W. (1995). *Behavior analysis of child development*. Reno, NV: Context Press.

Bijou, S.W., & Baer, D.M. (1965). *Child development: Universal stage of infancy* (Vol. 2). Englewood Cliffs, NJ: Prentice-Hall.

Bijou, S. W. (1996). The role of setting factors in the behavior analysis of development. In S. W. Bijou & E. Ribes (Eds.), *New directions in behavioral development*. Reno, NV: Context Press.

Bloom, K., D'Odorico, L., & Beaumont, S. (1993). Adult preferences for syllabic vocalizations: Generalizations to parity and native language. *Infant Behavior and Development, 16*, 109-120.

Bronfenbrenner, U., & Ceci, S. J. (1994). Nature-nur ture reconceptualized in developmental perspective: A bioecological model. *Psychological Review, 101*, 568-596.

Brunk, M. A., & Henggeler, S. W. (1984). Child influences on adult controls: An experimental investigation. *Developmental Psychology, 20*, 1074-1081.

Cairns, R. B., Elder, G. H., & Costello, J. E. (Eds.) (1996). *Developmental science*. New York: Cambridge University Press.

Cantor, N. L., & Gelfand, D. M. (1977). Effects of responsiveness and sex of children on adults' behavior. *Child Development, 48*, 232-238.

Chi, M. T. H., & Ceci, S. J. (1987). Content knowledge: Its role, representation, and restructuring in memory development. In H.W. Reese (Ed.), *Advances in child development and behavior* (Vol. 20, pp. 91-142). Orlando, FL: Academic Press.

Cohen, R., & Siegel, A.W. (Eds.) (1991). *Context and development*. Hillsdale, NJ: LEA.

Donohoe, J. W., & Palmer, D. C. (1994). *Learning and complex behavior*. Boston, MA: Allyn and Bacon Publishers.

Eckerman, C. O. (1993). Toddlers' achievement of coordinated action with conspecifics: A dynamic systems perspective. In L. B. Smith & E. Thelen (Eds.), *A dynamic systems approach to development: Applications*. Cambridge, MA: MIT Press.

Etzel, B. C. (1997). Environmental approaches to conceptual behavior. In D. M. Baer & E. M. Pinkston (Eds.), *Environment and behavior*. Boulder, CO: Westview Press.

Flavell, J. H., Miller, P. H., & Miller, S. A. (1992). *Cognitive development (3rd ed.)*. Englewood Cliffs, NJ: Prentice-Hall.

Fogel, A. (1990). The process of developmental change in infant communicative action: Using dynamic systems theory to study individual ontogenies. In J. Colombo & J. Fagen (Eds.), *Individual differences in infancy: Reliability, stability, and prediction*. Hillsdale, NJ: Erlbaum.

Fogel, A. (1991). *Infancy: Infant, family, and society*. Saint Paul, MN: West Publishing.

Fogel, A., & Thelen, E. (1987). Development of early expressive and communicative action: Reinterpreting the evidence from a dynamic systems perspective. *Developmental Psychology, 23*, 747-761.

Gewirtz, J., & Pelaez-Nogueras, M. (1996). In the context of gross environmental and organismic changes, learning provides the main basis for behavioral development. In S.W. Bijou & E. Ribes (Eds.), *New directions in behavioral development* (pp. 15-34). Reno, NV: Context Press.

Gewirtz, J., & Pelaez-Nogueras, M. (1998). Attention reinforcers in infant operant learning. Paper presented at the Association for Behavior Analysis Meetings, Orlando, FL.

Gleick, J. (1987). *Chaos: Making a new science*. New York: Viking.

Glenn, S. S. (1991). Contingencies and metacontingencies: Relations among behavioral, cultural, and biological evolution. In P.A. Lamal (Ed.), *Behavioral analysis of societies and cultural practices* (pp. 39-73). New York: Hemisphere.

Goldfield, E. C. (1995). *Emergent forms: Origins and early development of human action*. New York: Oxford University Press.

Haken, H. (1983). *Synergetics, an introduction: Nonequilibrium phase transitions and self-organization in physics, chemistry, and biology*. Berlin: Springer-Verlag.

Harrison, J. M. (1994). The representative animal. *The Behavior Analyst, 17*, 207-219.

Haynes, S. N., Blaine, D., & Meyer, K. (1992). Dynamical models for psychological assessment: Phase space functions. *Psychological Assessment, 7*, 17-24.

Heiby, E. M. (1995). Chaos theory, nonlinear dynamical models, and psychological assessment. *Psychological Assessment, 7*, 5-9.

Heiby, E. M. (1995). Assessment of behavioral chaos with a focus on transitions in depression. *Psychological Assessment, 7*, 10-16.

Hoyert, M. S. (1992). Order and chaos in fixed interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior, 57*, 339-363.

Hunziker, M. H. L., Saldana, R. L., & Neuringer, A. (1996). Behavioral variability in SHR and WKY rats as a function of rearing environment and reinforcement contingency. *Journal of the Experimental Analysis of Behavior, 65*, 129-144.

Johnson, M.H. (Ed.) (1993). *Brain development and cognition: A reader*. Oxford: Blackwell.

Keller, B. B., & Bell, R. Q. (1979). Child effects on adult's method of eliciting altruistic behavior. *Child Development, 50*, 1004-1009.

Kelso, J. A. S. (1995). *Dynamic patterns: The self-organization of brain and behavior*. Cambridge, MA: The MIT Press.

Lamal, P. A. (Ed.). (1991). *Behavioral analysis of societies and cultural practices*. New York: Hemisphere.

Landau, B., & Gleitman, L. R. (1985). *Language and experience: Evidence from the blind child*. Cambridge, MA: Harvard University Press.

Malagodi, E.F. (1986). On radicalizing behaviorism: A call for cultural analysis. *The Behavior Analyst, 9*, 1-17.

Malcuit, G., & Pomerleau, A. (1996). Operant learning and habituation in infants. In S.W. Bijou & E. Ribes (Eds.), *New Directions in Behavior Development* (pp.47-72). Reno, NV: Context Press.

Marr, J. (1996). A mingled yarn. *The Behavior Analyst, 19*, 19-34.

Montgomery, D. E. (1997). Wittgenstein's private language argument and children's understanding of the mind. *Developmental Review, 17*, 291-320.

Novak, G. (1997). *Developmental psychology: Dynamic systems and behavior analysis*. Reno, NV: Context Press.

Paniagua, F.A. (1997). Verbal-nonverbal correspondence training as a case of environmental antecedents. In D. M. Baer & E. M. Pinkston (Eds.), *Environment and behavior*. Boulder, CO: Westview Press.

Pelaez-Nogueras, M., Gewirtz, J. L., Field, T., Cigales, M., Malphurs, J., Clasky, S., & Sanchez, A. (1996). Infant preferences for touch stimulation in face-to-face interactions. *Journal of Applied Developmental Psychology, 7*, 199-213.

Pelaez-Nogueras, M., & Gewirtz, J. L. (1997). The context of stimulus control in behavior analysis. In D.M. Baer & E.M. Pinkston (Eds.), *Environment and behavior*. Boulder, CO: Westview Press.

Plomin, R. (1989). Environment and genes: Determinants of behavior. *American Psychologist, 44*, 105-111.

Plomin, R., & Daniels, D. (1987). Why are children in the same family so different from each other? *Behavioral and Brain Sciences, 10*, 1-16.

Rachlin, H. (1994). *Behavior and mind*. New York: Oxford University Press.

Redd, W. H., Winston, A.S., & Morris, E.K. (1977). A methodology for studying social stimulus functions in children. In B. C. Etzel, J. M. LeBlanc, & Baer, D. M. (Eds.), *New developments in behavioral research: Theory, method, and application* (pp. 257-278). Hillsdale, NJ: LEA.

Reese, H. (1996). How is physiology relevant to behavior analysis? *The Behavior Analyst, 19*, 61-70.

Ribes, E. (1996). Some thoughts on the nature of a theory of behavior development and its application. In S.W. Bijou & E. Ribes (Eds.), *New directions in behavior development* (pp. 35-46). Reno, NV: Context Press.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Sameroff, A. J., & Suomi, S. J. (1996). Primates and persons: Developmental understanding of social organization. In R. B. Cairns, G. H. Elder, & E. J.Costello (Eds.), *Developmental science*. New York: Cambridge University Press.

Sidman, M. (1960). *Tactics of scientific research: Evaluating experimental data in psychology*. New York: Basic Books.

Siegler, R. S. (1989). Mechanisms of cognitive development. *Annual Review of Psychology, 40*, 353-379.

Siegler, R. S. (1996). *Emerging minds: The process of change in children's thinking*. New York: Oxford University Press.

Siegler, R. S., & Crowley, K. (1991). The microgenetic method: A direct means for studying cognitive development. *American Psychologist, 46*, 606-620.

Smith, L. B., & Thelen, E. (1994). *A dynamic systems approach to Development: Applications*. Cambridge, MA: The MIT Press.

Sophian, C. (1997). Beyond competence: The significance of performance for conceptual development. *Cognitive Development, 12*, 281-304.

Staddon, J. E. R. (1993). The conventional wisdom of behavior analysis. *Journal of the Experimental Analysis of Behavior, 60*, 439-447.

Taylor, J. C., & Carr, E. G. (1992a). Severe problem behaviors related to social interaction 1: Attention seeking and social avoidance. *Behavior Modification, 16*, 305-335.

Taylor, J. C., & Carr, E. G. (1992b). Severe problem behaviors related to social interaction 2: A systems analysis. *Behavior Modification, 16*, 336-371.

Thelen, E. (1995). Motor development: A new synthesis. *American Psychologist, 50*, 79-95.

Thelen, E., & Smith, L. B. (1993). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: The MIT Press.

Tomasello, M., Kruger, A., & Ratner, H. (1993). Cultural learning. *Behavioral and Brain Sciences, 16*, 495-511.

Thompson, R. (1986). Temperament, emotionality, and infant social cognition. In J. V. Lerner, & R. M. Lerner (Eds.), *Temperament and social interaction in infants and children*. San Francisco: Jossey-Bass.

Tudge, J., Putnam, S., & Valsiner, J. (1996). Culture and cognition in developmental perspective. In R.B. Cairns, G.H. Elder, & E. J. Costello (Eds.), *Developmental science*. New York: Cambridge University Press.

van Geert, P. (1994). *Dynamic systems of development: Change between complexity and chaos*. New York: Harvester/Wheatsheaf.

Vaughn, M. E., & Michael, J. L. (1982). Automatic reinforcement: An important but ignored concept. *Behaviorism, 10*, 217-227.

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