U-Shaped Functions: Artifact or Hallmark of Development?

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Article:

The articles in this collection consider one very interesting puzzle of development: U-shaped developmental functions. At some point during development, an organism might exhibit what seems like a regression from its expected developmental trajectory and, according to continuity models of development, this is aberrant. In this special issue, apparent regressions in behavior across a wide range of developmental phenomena are discussed. Gershkoff-Stowe and Thelen (this issue) present evidence that infants will reach correctly on B trials before they reach perseveratively, and that young children's naming errors actually increase with age before achieving a period of stability. Namy, Campbell. and Tomasello (this issue) show that even though 26-month-olds have difficulty with arbitrary gestures, younger and older children do not. Finally, Cashon and Cohen (this issue) show that the ability to integrate facial features follows a U-shaped developmental pattern for inverted faces. but oddly enough. an N-shaped pattern for upright faces. These counter-intuitive findings, and many others like them, seem to call for revisions to the common theoretical conception of development as a monotonically increasing. ever-improving process. In line with the contributors, our main thesis is that regressions in the developmental trajectory of particular behavioral traits are, if anything. the quintessential hallmark of the *developmental process* rather than mere artifacts of development.

The main premise of our thesis is based upon a rejection of the old idea that development is a continuous process whose endpoint defines everything that comes before it. This kind of adultomorphic perspective forces one to view earlier behaviors and functions as immature versions of the adult functions. The articles in this issue provide several examples of this kind of "old" thinking. For example, the ability of a 5-month-old to reach "correctly" on a B trial has been interpreted as the consequence of immature reaching abilities as compared to older children and adults (Gershkoff-Stowe & Thelen, this issue). Likewise, 18-month-olds' propensity to properly learn an arbitrary gesture presumably reflects an immaturity of symbolic awareness (Namy et al.. this issue). Finally, 4-month-olds' ability to process faces in an integrative manner is supposedly immature because it may be unstable and limited in capacity (Cashon & Cohen, this issue).

We believe that this kind of thinking is wrong-headed mainly because it leads one away from understanding the very processes that underlie development. As so ably described by Gershkoff-Stowe and Thelen (this issue), development is a complex and dynamic process characterized by structural and functional re-organization resulting in non-linear and emergent outcomes. We fully agree with this characterization of development and believe that U-shaped trajectories are an essential feature of development. In our view, however, the dynamical systems approach is conceptually incomplete when it comes to interpreting the essential rather than artifactual role that U-shaped developmental trajectories play in ontogenesis. On the one hand, the dynamical systems approach provides a useful heuristic for thinking about the proximal causes of developmental change. It holds that the proximal causes of instability are growth. experience, and the asynchronous development of subsystems. For example, as the child grows, new sensory, perceptual. cognitive, and motor abilities emerge that then provide the child with new opportunities for further development. Often, however, re-integration of subsystems to achieve a new state of organization requires that the organism pass through states of disorganization, or what appear to be less mature forms of behavior.

A particularly good example of the re-integration of sub-systems following a period of disorganization is illustrated by the classic finding of young children's overregularization of the past tense (e.g., Bybee & Slobin, 1982; Ervin & Miller, 1963). Although young children arc initially correct when producing the past tense of irregular verbs (e.g.. ring —> rang), subsequently they go through a period where they overregularized (e.g.. ring —> ringed). In the final stage. they begin to systematically use the correct past tense again. One popular explanation is that children produce past tense forms based on two processes: memorization and rule following. Initially, children rely mostly on memorization, which leads to correct usage of the past tense. The tendency to overregularize the newly learned "add *-ed"* rule overrides the previously learned behaviors and leads to an increase in errors. Eventually. children are capable of integrating both processes. and successfully add *—ed to* the regular verbs while memorizing the proper past tense for the irregular verbs (Bybee &1982: but see Rumelhart & McClelland. 1986, for an alternative perspective).

Although the dynamical systems view offers a sensible explanation for the proximal causes of developmental re-organization, we believe that this is only a part of the story. In our view. the U-shaped character of development also may reflect the influence of distal (i.e., evolutionary) influences. To understand how distal influences might contribute to U-shaped developmental trajectories. it is useful to consider the concept of *ontogenetic adaptations* proposed by Oppenheim (1981). This concept holds that at any particular time in development an organism is well-adapted to its current environmental context. According to an epigenetic systems view of development (Gottlieb, 1992). the organism achieves this state of adaptation by a process of structural and functional reorganization that consists of the complex. bi-directional co-action of factors internal and external to the organism at all levels of organization, from molecular. through cellular, to organismic. Importantly. this re-organization takes into account not only the organism's contemporary exigencies but past ones as well (i.e., early experience). During times of homeostasis and stability (what are termed attractor states in dynamical systems theory). the organism functions perfectly well vis-a-vis its milieu.

Oppenheim illustrates this point by describing the metamorphosis of a tadpole into a frog. Both organisms are well-adapted to their milieu: the tadpole is well-adapted to its aquatic environment and to the need to breathe in water and the frog is well-adapted to its terrestrial existence and to its need to breathe in air. Although the metamorphosis from a tadpole to a frog is an extreme example of developmental reorganization and ontogenetic adaptation, Oppenheim (1981) argued that these same principles hold for other species. Indeed, two examples from human development come to mind. One is an example of ontogenetic adaptations that Lewkowicz and Turkewitz (1980) have provided from their investigation of intersensory perception in the human neonate. They found that neonates respond spontaneously to the intensity-based equivalence of auditory and visual inputs whereas adults do not. What makes these findings of particular relevance to the concept of ontogenetic adaptations is that even though neonates exhibit a nascent form of intersensory integration, they cannot make other, higher-level types of intersensory matches (Lewkowicz. 2000). In contrast, older children and adults are obviously capable of all types of intersensory integration. Lewkowicz and Turkewitz argued that the ability to perceive intensity-based intersensory equivalence provides a neonate an adaptively meaningful way to begin to learn about the perceptual unity of his or her world in a "buffered" and measured way. In other words, the neonate is not viewed as an organism that is severely limited by its sensory immaturity and limitations. Rather, the neonate and its limitations are seen as an ontogenetic adaptation that permits development to proceed in an orderly and measured way (Turkewitz & Kenny. I9821. The neonate is not an immature version of an adult hut a different organism whose functions are governed by different but equally well-adapted mechanisms (Schneirla, 1949).

The second example comes from children's use of the past-tense (see above). Like the tadpole, young children who correctly use the appropriate past-tense are well-adapted given their developmental history and current milieu. Then, just like the tadpole sprouts legs and wobbles about clumsily as it begins to adapt to its new developmental stage, children first show an increase in errors as the past tense rules are used and overregularized but then, like the well-adapted frog, children learn to integrate previous experience with current knowledge and begin to show appropriate use of the past-tense rule.

It should be noted, however, that by itself the concept of ontogenetic adaptations poses a theoretical problem because it suggests that an organism has no reason to change or improve. After all, change is the *sine qua not* of development. The solution to this problem resides in the fact that the developmental manifold consists of a nexus of biologically and environmentally driven changes occurring in concert with one another, and thus the developing organism constantly finds itself in a milieu that always offers new opportunities and challenges. A developing organism that takes advantage of such opportunities is evolutionarily better prepared to succeed than one that does not. This brings us to the central point of our commentary. By incorporating Oppenheim's (1981) concept of ontogenetic adaptations into our thinking about development we are forced to think about not only the proximal causes of developmental change but distal ones as well. In our opinion, the dynamical systems view accounts very well for the proximal causes of developmental change: individuals soft-assemble their behavior based on past experience, contemporary pressures, and their functional and structural capabilities. What is missing, however, is an answer to the question of what determines whether a particular behavior that is soft-assembled is appropriate or not. Developing organisms certainly engage in a lot of misguided behaviors. It is our contention that what ultimately determines the appropriateness of a given behavior is its evolutionary adaptability within a species-specific range (Gottlieb. 1991).

If the notion that evolution selects for ontogenies (Gottlieb, 1992) is accepted, then those ontogenies that include successful patterns of behavioral adaptation to the individual's contemporary demands are, by definition. evolutionarily adaptive as well. In other words, it is the organism's *flexibility* to re-organize when necessary to the changing exigencies of its functional capacities and milieu that is evolutionarily adaptive and is likely to be favored over ontogenies that are more rigid. In this way. what seem like developmental regressions actually become essential components of an ontogenetic and evolutionary developmental trajectory. In other words, an epigenetic systems point of view of development that incorporates the concept of ontogenetic adaptations not only provides ontogenetic justification to U-shaped developmental trajectories but also brings evolutionary considerations into the picture.

In summary, current research continues to yield impressive findings of apparent behavioral regressions. These kinds of findings pose fundamental challenges to our theoretical conceptions of development (Lewkowicz & Lickliter, 2002). As the contributors to the current collection have shown and as we have argued here, it is necessary to shift our theoretical focus away from the phenomena themselves towards a focus on the mechanisms and processes underlying developmental change. In our view, such a shift will ultimately have to incorporate an understanding of both proximal and distal influences on the development of behavior.

Notes:

[1]Overall. overregularization errors are uncommon, occurring in roughly 2.5% of instances where children use irregular forms and remaining roughly constant until middle childhood. Nonetheless, children do make statistically more overregularization errors than they do earlier in childhood, which justifies classifying the phenomenon as U-shaped (Marcus et al.. 1992).

REFERENCES

Bybee. J.. & Slobin, D. (1982). Rules and schemes in the development and use of the English past tense. *Language.* 58.265-289.
Ervin. S. M.. & Miller. W. R. (1963). Language development. In H. W. Stevenson (Ed.). *Child psychology: The sixty-second yearbook of the National Society for the Study of Education, Part I* (pp. 108-143). Chicago: University of Chicago Press.
Gottlieb. G. (1991). Experiential canalization of behavioral development: Theory. *Developmental Psychology. 27.* 35-39.
Gottlieb. G. (1992). *Individual development & evolution.* New York: Oxford University Press. Lewkowicz, D. J. (2000), The development of intersensory temporal perception: An epigenetic systems/limitations view. *Psychological Bulletin. 126.* 281-308.
Lewkowicz, D. J.. & Lickliter. R. (Eds.1. (2002). *Conceptions o f development: Lessons faun the laboratory.* New York: Psychological Press.

Lewkowicz, D. J.. & Turkewitz. G. (1980). Cross-modal equivalence in early infancy: Auditory-visual intensity matching. *Developmental Psychology, 16,* 597-607.
Marcus, G. F., Pinker, S., Ullman. M.. Hollander. M.. Rosen, T. J., & Xu, F. (1992). Overregularization in language acquisition. *Monographs of the Society for Research in Child Development,* 57(4. Serial No. 228).
Oppenheim. R. W. (198 I). Ontogenetic adaptations and retrogressive processes in the development of the nervous system and behavior. a neuroembryological perspective. In K. J. Connoly & H. F. R. Prechtl (Eds.), *Maturation and development: Biological and psychological perspectives* (pp. 73-1(X9). Philadelphia: J. P. Lippincott.
Rumelhart. D. E., & McClelland, J. L. (1986). On learning the past tenses of English verbs. In J. L. McClelland, D. E. Rumelhart. & the PDP Research Group (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition: 1431 2. Psychological and biological models* (pp. 21C>-2711. Cambridge. MA: Bradford Books / MIT Press.
Schneirla, T C. (19491. Levels in the psychological capacities of animals. In R. W. Sellars. V. J. McGill. & M. Farber (Eds.). *Philosophy for the futon'* (pp. 241-286). New York: Macmillan.
Turkewitz. G.. & Kenny, P. A. (1982). Limitations on input as a basis for neural organization and perceptual development: A preliminary theoretical statement. *Developmental Psychobiology. 15.* 357-368.