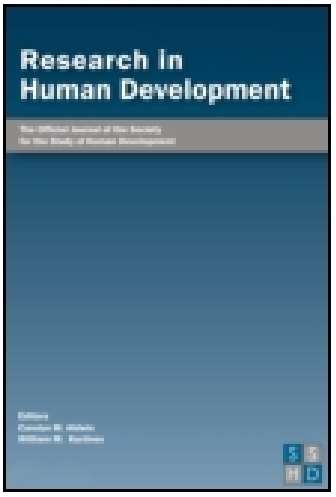


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# Fundamental Concepts and Methods in Developmental Science: A Relational Perspective

Willis F. Overton [a] & Richard M. Lerner [b]
[a] Temple University
[b] Tufts University
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COMMENTARY

# Fundamental Concepts and Methods in Developmental Science: A Relational Perspective

Willis F. Overton
*Temple University*

Richard M. Lerner
*Tufts University*

The articles in this issue represent an advance towards the goal of articulating a coherent contemporary Developmental Science. Our commentary reflects on and elaborates each contribution. The articles demonstrate a commitment to the principles of the meta-theory of a scientific paradigm termed "Relationism." After describing the ontological-epistemological assumptions of the relational model, we describe how these categories lead directly to a characterization of the organism and development that defines "relational developmental systems." The categories and characterizations result in a relational vocabulary; we discuss features of each of the articles in the context of this vocabulary.

Each of the articles in this issue of *Research in Human Development*, and the issue as a whole, represents an advance toward the goal of articulating a coherent developmental science that has shed the shackles of the classic Cartesian-Newtonian-mechanistic scientific paradigm and has embraced a relational paradigm as a more productive context for advancing the scientific knowledge of the development of living organisms. Greenberg (2014a) contributes to this project by exploring several of the central concepts of relational developmental systems, including self-organization, epigenesis, and emergence. Michel's (2014) contribution illustrates the importance of a contemporary relational psychobiological approach, and its attendant empirical consequences, as contrasted with the futile Cartesian splitting of gene and environment. Witherington (2014) issues a critical—and too often ignored—warning that constant ontological and epistemological vigilance is necessary if the new relational science is to avoid regression

Address correspondence to Willis F. Overton, PhD, Psychology Department, Temple University, Philadelphia, PA 19122. E-mail: Overton@temple.edu

to stifling Cartesian categories. Molenaar's (2014) contribution alerts us to the centrality of the individual person in human development and nonlinear processes in relational developmental science, and to the fact that significant advances are being made in the construction of new quantitative models designed to better assess the development of the individual.

We find little to disagree with in any of these contributions and, consequently, our comments take the form of some reflections and elaborations. It will come as no surprise to the readers of this issue that we seriously embrace the relational scientific paradigm, which we have referred to as relationism and relational developmental systems (e.g., Lerner & Benson, 2013; Lerner & Overton, 2008; Overton 2010, 2013; Overton & Lerner, 2012). Briefly, the primary ontological and epistemological categories of this paradigm are (1) process (vs. Cartesian substance), (2) becoming/being (vs. Cartesian being), (3) holism (vs. Cartesian atomism), (4) relational analysis (vs. Cartesian either/or split analysis), (5) multiple perspectives (vs. Cartesian dualistic split objectivism– subjectivism), (6) coaction (vs. Cartesian split interaction), and (7) multiple forms of determination (vs. Cartesian-Newtonian efficient/material causality).

As a derivation from these relational categories, the relational developmental systems paradigm characterizes the living organism as a spontaneously active, self-creating (autopoetic, enactive), self-organizing, and self-regulating nonlinear complex adaptive system. The system's development occurs through its own embodied activities and actions operating in a lived world of physical and sociocultural objects, according to the principle of probabilistic epigenesis. This development leads, through positive and negative feedback loops created by the system's action, to increasing system differentiation, integration, and complexity, directed toward adaptive ends.

The categories and characterizations of relational developmental systems are abstract and form the frame within which the meanings of lower order concepts become defined. As Searle (1992) pointed out, categories and characterizations of the sort we describe lead to vocabularies, and these vocabularies ultimately affect the way we think about issues and investigate empirical questions.

## THE ACTIVE ORGANISM

Consider, for example, the characterization of the organism as a complex organized system that is inherently active. If this characterization is seriously embraced, than the concepts *response, elicit*, and *evoke* become—except under highly restricted conditions—virtually meaningless, and they are replaced by the concepts *activity* (applied to a biological level of organization) and *action* (applied to a psychological level, and entailing intention or goal direction). Further, there is rarely a stimulus object or event, in the sense of an environmental cause that does the eliciting or evoking. In place of the stimulus, the concepts *affordance, resource*, or *asset* are employed to designate "opportunities for action."

Greenberg's (2014b) example of Kuo's work with chick embryos presents an illustration of how activity and action impact on issues and research. As Greenberg (2014b) points out, Kuo's investigations discovered that the pecking behavior of the newly hatched chick was not the product of some genetic determinism, but rather the outcome of the embryonic chick's spontaneous activity prior to hatching. However, from a relational developmental systems perspective the embryonic behavior itself was not, in fact, the product of "of something that was *happening to* it [the embryonic chick]" (Greenberg, 2014b, p. 2, emphasis added). The embryonic activity was actually something "the chick was doing." That is, the organized system (embryonic

chick) qua organized system is inherently active and, whereas this organized active system can be described with respect to part–part relations (i.e., "because of the musculature of the head, as it rose and fell, the beak would open and close . . . and the reflexive action of peristalsis would cause the embryo to swallow" Greenberg, 2014b, p. 2), these relations in no way nullify the centrality of the chick's inherent activity in the overall process.

## THE CONCEPT OF EXPERIENCE

The active organism characterization also affects the meaning of *experience,* a concept that is central to the Greenberg (2014a) and Michel (2014) articles. The conventional Cartesian meaning of experience is an event or object (stimulus) that is split off from and antecedent to the activity/action of the organism. However, as William James (1912) pointed out, experience is a "double-barreled" (p. 10) concept and, as John Dewey (1925) elaborated, "It includes what men do and suffer, what they strive for . . . and endure, and also how men act and are acted upon" (p. 10). The Cartesian understanding of *experience* was exclusively on "how men [sic] are acted upon," a split-off concept that entailed efficient causal forces (stimuli—endogenous or exogenous) that were taken to explain behavior and development. As a consequence, from the Cartesian perspective it was reasonable to split off nature from nurture (experience). The relational active organism position focuses on the individual, on "how men [sic] act." Within the relational frame embodied organized activity or action is the definition of experience. Thus, following Greenberg's discussion of Gottlieb's work (Greenberg, 2014b), the relational position is that, at the microscopic level, all development is the result of, and all behavior is identified as, experience (i.e., embodied organized action), whether these experiences are obvious or "nonobvious" (Greenberg, 2014b, p. 3). Hence, there is no such thing as "nature versus nurture," and there is no such thing as "nativism versus empiricism," there are only the organized embodied activities and actions of the system (experience), whether these operate on a biological, psychological, or cultural level of organization. It is, for example, not the case that "early perceptual and behavioral asymmetrical biases *can provide experiences* relevant to the formation of . . . nascent sensorimotor systems" (Michel, 2014, p. 37, emphasis added); rather, it is that the experiences entailed by early perceptual and behavioral asymmetrical biases constitute the basis for the formation of . . . nascent sensorimotor systems." Similarly, we do not "inherit . . . our . . . experiences" (Michel 2014, p. 42); rather, experience (embodied activities and actions) constitutes the fundamental processes that make inheritance possible.

## THE CONCEPTS OF INNATE AND MATURATION

Taking seriously, the relational system characterization of the living organism and its development renders other Cartesian-inspired concepts meaningless and/or scientifically counterproductive; foremost among these being the concepts *innate* and *maturation*. Unless used in its strict sense (i.e., present at birth), and it rarely is used this way, *innate* implies that a characteristic is acquired through a split-off encapsulated evolutionary or biological process, independent of experience. But as illustrated in the Greenberg (2014a) and Michel (2014) articles, and as outlined above, developmental psychobiology has already demonstrated that that any characteristic is the outcome of a long and continuous epigenesis entailing embodied activities and actions (experiences),

beginning at conception and continuing through prenatal and postnatal phases of development, as well as across the life span. Thus, for example, various action patterns present at birth, including the nascent form of hand-use preference, have a long experiential history, as is nicely demonstrated in detail by Michel in this issue.

The concept *maturation* is analogous to *innate*, for here too an appeal is made to a split-off encapsulated biological determinism, independent of experience. Maturation was popular many years ago, even among some of the most advanced patriarchs of relational thought For example, Piaget (1970) discussed one of the three "classical factors of development" as being "maturation" (p. 719), and Schneirla (1957) differentiated maturation and experience by maintaining that "*maturation* connotes processes contributed through growth and differentiation" (p. 102). However, in today's relational approaches, the concept *maturation*, like the concept *innate,* functions as a blind spot choking off, conceptually and empirically, a full understanding of development through the coactions of biology←→environment in the context of epigenesis.

## Evolutionary Psychology and the Innate

Today, there are instances where, although the term *innate* is not explicitly used its Cartesian-split biological meaning, it is nonetheless awarded a central role in the explanation of various human characteristics. A prominent example is found in the field evolutionary psychology (EP). Despite the abundant evidence that epigenetic processes and features of the relational developmental system, such as embodied actions and relative plasticity, provide the bases of evolutionary and developmental change (e.g., Gissis & Jablonka, 2011; Ho, 2010; Jablonka & Lamb, 2005; Keller, 2010; Meaney, 2010; Misteli, 2013; Slavich & Cole, 2013), proponents of EP claim that "everything from children's alleged dislike of spinach to our supposed universal preferences for scenery featuring grassland and water derives from [the] mythic human origin in the African savannah" (Rose & Rose, 2000, p. 2). These claims are predicated on the basis of the assertion that one can explain,

> all aspects of human behaviours, and thence culture and society, on the basis of universal features of human nature that found their final evolutionary form during the infancy of our species some 100-600,000 years ago. Thus for EP, what its protagonists describe as the "architecture of the human mind" which evolved during the Pleistocene is fixed, and insufficient time has elapsed for any significant subsequent change. In this architecture there have been no major repairs, no extensions, no refurbishments, indeed nothing to suggest that micro or macro contextual changes since prehistory have been accompanied by evolutionary adaption. (Rose & Rose, 2000, p. 1)

Examples of the claims of EP pointed to by Rose and Rose (2000) occur in writing about what is termed "paternal investment theory" (e.g., Belsky, 2012; Belsky, Steinberg, & Draper, 1991; Draper & Harpending, 1982, 1988). For example, Ellis, Schlomer, Tilley, and Butler (2012) claimed that,

> paternal investment theory links low male parental investment to more aggressive and hypermasculine behavior in sons and more precocious and RSB [risky sexual behavior] in daughters (Draper & Harpending, 1982, 1988). The assumption is that natural selection has designed boys' and girls' brains to detect and encode information about their fathers' social behavior and role in the family as the basis for calibrating sociosexual development in gender-specific ways. (p. 329)

The purported mechanism for what Ellis et al. (2012) termed this evolutionary-developmental phenomenon is that there is

> a unique role for fathers in regulating daughters' sexual behavior. The theoretical basis for emphasizing father effects is (a) that the quality and quantity of paternal investment is, and presumably always has been, widely variable across and within human societies; (b) this variation recurrently and uniquely influenced the survival and fitness of children during our evolutionary history . . .; and (c) variability in paternal investment, much more than maternal investment, was diagnostic of the local mating system (degree of monogamy vs. polygyny) and associated levels of male-male competition. . . . The mating system is important because more polygynous cultures and subcultures are characterized by heightened male intrasexual competition, dominance-striving, and violence, with concomitant diminution of paternal involvement and investment (Draper & Harpending, 1982, 1988). In turn, female reproductive strategies in this context are biased toward earlier sexual debut, reduced reticence in selecting mates, and devaluation of potential long-term relationships with high-investing males, all of which translate into more RSB. (p. 329)

Similarly, Pinker (2011), describing what he characterized as the "distinctive mechanistic process" (p. 613) of natural selection, reflects also this Cartesian-split thinking and, as well, ignoring the above-noted evidence about epigenetics, embodiment, and relative plasticity, states that he assumes that

> human nature, in the sense of the cognitive and emotional inventory of our species, has been constant over the ten-thousand year window in which declines of violence are visible, and that all differences in behavior among societies have strictly environmental causes. That is a standard assumption in evolutionary psychology. (p. 612)

In contrast to these EP claims, within the relational developmental systems perspective, transmission across generations is accounted for by the plastic-embodied processes of the individual functioning in a mutually-influential relation with his or her physical and cultural context (Lerner & Overton, in press). Embodiment constitutes the basis for epigenesis within the person's life span (Gottlieb, 1997, 1998), including qualitative discontinuity across ontogeny in relations among biological, psychological, behavioral, and social-cultural variables. Evidence for the relative plasticity of human development within the integrated levels of the ecology of human development makes biologically reductionist or split accounts of parenting, offspring development, sexuality, or violence implausible, at best, and entirely fanciful, at worst.

There are, of course, other concepts beyond experience, maturation, and innate—whether explicit or implied as in EP—that can reflect Cartesian split categories. One of the most problematic of these is the concept *interaction*.

## THE CONCEPT *INTERACTION*

The concept *interaction*, as used in developmental science, straddles the Cartesian–relational line and as a consequence introduces a great deal of conceptual confusion in scientific discussions. Within the Cartesian paradigm, interaction entails split and dichotomized pure forms (e.g., genes and environment), together composing a third (e.g., a phenotype), with this composition being constituted in a strictly linear additive manner. Many statistical models find this use meaningful.

For example, in Michel's (2014) article there is a discussion of gene-by-environment interaction or G x E, where it is understood that the *X* represents multiple additions and a phenotype is completely decomposable into G factors, E factors, and additive G x E factors. From a relational perspective, however, there are no pure forms and epigenesis is not linear or additive. From a relational perspective, phenomenological objects and their parts stand in holistic relations to each other; parts get their meanings from wholes, wholes get their meanings from parts, and wholes differ in novel ways from the sum of their parts (see Greenberg, 2014b). Wholes and parts interpenetrate, interdefine, and fuse (Tobach & Greenberg, 1984), and it is thus meaningless to consider constructing or deconstructing the whole by adding or subtracting parts. Rather than isolated pure forms interacting, organic wholes *coact* and *coconstruct*. As a consequence, the relational developmental systems paradigm limits, wherever possible, interaction to its statistical meaning and in all other situations discusses organismic characteristics and development in terms of concepts *coactions* and *coconstructions*.

In many ways Michel's (2014) article stands, conceptually and empirically, as a model of the relational developmental systems perspective. However, were we to suggest edits to enhance the relational coherence of the article, we would rewrite several sentences. For example, while discussing "gene by environmental interaction (GBEI)" (Michel 2014, p. 37) is fine, we would suggest the edit "Developmental psychobiologists (DPB) have long argued that phenotypes develop from the ~~interaction~~ *coaction* of . . ." (Michel, 2014, p. 38). And for another edit we would choose would be, "Gottlieb's (1999) illustration of the developmental manifold . . . acknowledges that the relation of gene expression to manifest phenotype is a consequence of the ~~interaction~~ *coactions* . . ." (Michel, 2014, p. 39). And finally, we would suggest the critical edit, "Developmental psychobiological research assumes that behavior develops from the ~~interaction~~ *coaction* of the organism . . . and its physical and social milieu" (Michel, 2014, p. 41).

## THE CONCEPT *CAUSALITY*

The unbreakable coactions and coconstructions between organism and its contexts are symbolized in relational developmental systems as *organism*←→*context*, indicating that the organism is always contextually situated, and that causality is reciprocally bidirectional (see Michel, 2014, as an illustration). This concept of causality stands in contrast to the Cartesian concept, which admits no forms of explanation other than unidirectional, linear, and additive sequences of efficient and material causes (e.g., see the above-cited statements by Pinker, 2011).

The reciprocal bidirectional framework allows for circular causality as well as one particular variant of circularity causality, downward causality. This latter form of determination is particularly relevant to the case that Witherington (2014) makes concerning the need in a relational system for a top-down explanation to avoid falling into what would be a reductionist trap of exclusive bottom-up explanation.

## SELF-CREATION AND SELF-ORGANIZATION

Witherington's (2014) insight that the central relational developmental systems concept of self-organization has narrowed over the years is critical, as is his description of the reasons for,

and implications of, this narrowing. Self-organization is increasingly being understood exclusively as a bottom-up process. Thus, for example, Friedenberg (2009) explicitly stated that a general feature of self-organizing systems, "is that complex global behavior can rise from simple local interactions between parts" (p. 54) and that "self-organization . . . is an example of a bottom-up organization" (p. 61). And van Geert (2003) refers to self-organization as "a process of creating structure" (p. 654). As Witherington (2014) demonstrates, if this process were to remain as the exclusive formative process of development, then all higher order forms of organization would be ultimately reducible to simple local activity.

Relational developmental systems guards against this new reductionism in two closely related ways: (1) by insisting that all activity and acts are embodied; *embodiment* constituting a dynamic organization or structural whole that contextualizes (effects a downward causality on) part–part local activity and sets the conditions for part–whole and whole–part relations (circular causality) and (2) by recognizing *adaptive autopoiesis* (i.e., self-creation) (Di Paolo, 2005; Maturana & Poerksen, 2004) as the top-down process that forms a relational complementarity with the bottom-up process of self-organization.

Consider the issue of processes in the context of structure-function relations (see Witherington, 2011). Structure (organization or pattern) and function (activity/action) constitute an indissociable relational complementarity. At any level of functioning (activity/action), there is structure (organization/pattern) and at any level of structure, there is functioning. Thus, though self-organizing processes (activity/acts) are coacting part to part and leading to an emergent novel structure-function relation, the self-organizing activity itself operates within and is defined by its current structure. This is the structural determinism (i.e., "changes of state in a system always operate in the present as a result of its current structure"; Di Paolo, 2005, p. 434) of adaptive autopoiesis. Further, with the emergence of novel structure-function relations, the novel functional organization forms the structural determination of itself and all lower structure-function levels.

The top-down/bottom-up process could be demonstrated at any level from the genomic to the cultural; consider, however, the newborn child. Following 9 months of prenatal development, the newborn demonstrates patterns of action (i.e., structure-function). To emphasize, these are not random movements but patterns of action. Consequently, from the beginning—whenever that may be—there is a structural determinism, a top-down process that serves as context for the bottom-up process of self-organization.

The initial action patterns of the infant are sensorimotor in nature. With further experience (part–part, part–whole, whole–part), these action patterns generate emergent novel patterns. Thus, for example, at around 2 years a new pattern of interiorized actions emerges and, hence, there is a new structure-function relation. This pattern is usually termed the symbolic or semiotic function, and it is manifested in the child's newfound ability to evoke true symbols (i.e., representations that are detached from, and arbitrary with respect to, the object or event that they represent). Given this new ability, the child begins to think (i.e., manipulate symbols), and thinking forms the context within which sensorimotor patterns now operate. A new level of organization serves as context for itself and for lower levels and the iterations of this indissociable top-down/bottom-up process continue throughout the life span. Learning to ride a bicycle is one example of the downward causality of this twin relational process. Bike riding is clearly a sensorimotor skill, and yet it is framed by thought processes (e.g., "turn left at the corner," "stop at the red light").

This relational framing of self-creation and self-organization illustrates the relational developmental systems paradigm's ontological commitment to organization and activity/action. No matter how deep analysis goes—even to the molecular level—there will always be organization and the organization will always stand in an indissociable relation to activity/action. One can agree with Molenaar (2014) about the variations generated by self-organizing bifurcations (phases, stages). However, the system is never symmetrical or uniform; there are always self-creating processes operating in conjunction with self-organizing process.

## STUDYING THE INDIVIDUAL: ADVANCES IN METHODOLOGY

As all of the forgoing discussion suggests, the relational developmental systems paradigm focuses on the development of the individual; the study of intraindividual change of the complex adaptive system is a hallmark of this approach. Because the system is, as Molenaar (2014) discusses, nonlinear, new statistical models have been needed in the service of person-oriented developmental research. It was only a few years ago that one of the present authors argued that "the relational developmental systems approach has lacked a toolbox of nonlinear analytic methods and, as a consequence, has often been in the unfortunate position of attempting to express nonadditivity effects in an additive context" (Overton, 2011, p. 260). Through the work of Molenaar, his colleagues, and others, this situation has today changed dramatically.

Two recent texts, one edited by Molenaar and Newell (2010) titled *Individual Pathways of Change: Statistical Models for Analyzing Learning and Development*, the other edited by Molenaar, Lerner, and Newell (2014) titled *Handbook of Developmental Systems Theory and Methodology,* provide development science with several statistical models and techniques for the implementation of the models. These books cover a wide range of topics relevant to the study of the individual relational developmental system, including models of nonlinear epigenetic variance in development and nonlinear developmental trajectories.

Along with these texts, there is the handbook that, through six editions was titled the *Handbook of Child Psychology*, but for the new seventh edition is titled the *Handbook of Child Psychology and Developmental Science*. This handbook contains several chapters directly dedicated to methodological issues relevant to relational developmental systems. The *Handbook* (Volume 1) includes a number of relevant chapters: a chapter by Molenaar and Nesselroade (in press) that, among other topics, presents an extended discussion of nonlinear dynamic systems modeling of developmental stage transitions and a chapter by Ram and Grimm (in press) that discusses growth curve models, linear and nonlinear, along with longitudinal factor analysis. This chapter also includes an extended appeal to the field of developmental science to embrace nonlinearity and employ differential equations to describe the complexity of development. Ram and Grimm argue that "across fields, change processes are almost always formulated as *differential equations*. Calculus provides powerful tools for describing and explaining the behavior of dynamically changing processes"; A chapter by von Eye, Bergman, and Hsieh (in press) examines person-oriented models, including a discussion of nonlinear multilevel models, nonlinear structural equation models, and alternatives. Finally, a chapter by Witherington (in press) discusses dynamic systems, including a mathematical theory—nonlinear dynamic systems—that provides tools and concepts "for describing and understanding change in all its complexity, grounded in the importance of variability and nonlinearity".

## CONCLUSIONS

With the publication of these texts and chapters it is safe to say that there has been a quantum leap forward in filling our methodological toolbox with nonlinear statistical models as well as with some close approximations to these models. Along with the continuing advancement on this front of creating new methodological tools, developmental science frankly needs a serious educational marketing campaign designed to teach developmental scientists in general and young scientists particularly (1) that there are available new, well-grounded conceptual tools and new, well-grounded methodological tools to match the conceptual tools; (2) that research can now be better designed to answer questions about the development of individuals as complex adaptive systems; (3) exactly how to implement (use) the new conceptual and methodological tools; and (4) that the standard methodological tools work only under very narrow conditions.

Taken as a whole, the articles in this issue of *Research in Human Development* represent, conceptually and methodologically an excellent step forward in such a campaign. Other steps are needed as well. Our scholarly societies can also provide ways forward, and perhaps again especially for young scientists and graduate students. The Society for the Study of Human Development (SSHD), which is the sponsor of this journal, is a case in point. Webinars linked to each issue of *Research in Human Development*, programs at the biennial meeting that are specifically designed to instruct developmental scientists in the four above-noted knowledge/skill sets, and opportunities to network with senior scholars and other junior scholars are among the SSHD programs intended to pursue the campaign we have described. In addition, the Emerging Scholars Committee of SSHD, composed of newly "minted" doctoral-trained developmental scholars and graduate students, continues to devise new ways to further this campaign.

In sum, there is a rapidly filling conceptual and methodological tool box; there are increasing numbers of articles, monographs, textbooks, and reference works published about relational developmental systems models and methods; there is evidence of a commitment of scholarly organizations to enact developmental science framed by a relational paradigm (Overton & Lerner, 2012); and there are an increasing number of laboratories across the United States and internationally committed to training the next generation of developmental scientists within this frame. As such, we are optimistic that split, reductionist, and mechanistic conceptions of human development will go the way of the structuralism of Wundt or the phrenology of Gall and Spurzheim (Boring, 1950): They will be approaches remembered as part of the history of our field but playing no role in the future progress of developmental science.

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