Epilogue

Human Development 2019;63:264–276
DOI: 10.1159/000504319

Published online: November 21, 2019

Developmental Dynamics: Past, Present, and Future

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Keywords
Dynamic systems approaches · Organicist approaches · Organization · Process · Powers · Time scales

Abstract
At the end of the 20th century, as new tools and techniques from the interdisciplinary field of nonlinear dynamics began enjoying increased application to the study of development, interest in dynamics flourished in the developmental sciences. In the eyes of many prominent dynamics thinkers of the time, these new dynamics approaches – by virtue of their grounding in time and variability – not only established a thoroughgoing process orientation to development but also stood in marked opposition to the structural, or organizational, focus that had marked classic organicist and systems treatments of development from earlier in the century. Treatments of developmental dynamics today, however, are embarking on exciting new ways to integrate the organizational focus of classic systems accounts with modern principles of nonlinear dynamics. As a consequence, today's dynamics orientations are taking seriously the explanatory significance of phenomena like purposiveness, end-directedness, normativity, and subjectivity that characterize organisms as unique levels of process organization. Many challenges lie ahead for fully realizing such an integration, and we highlight two noteworthy conceptual issues that today's treatments need to confront: (1) the notion of abilities or powers as potentials for action and what it means for "potential" to explain action; and (2) the notions of real time change, developmental time change, and what it means for these different timescales to interrelate.
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Introduction

Twenty-five years ago, Esther Thelen and Linda B. Smith published their seminal 1994 book *A dynamic systems approach to the development of cognition and action*. It remains one of the most influential and trendsetting treatments in recent history of a

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dynamics orientation to the study of development. In their treatment, Thelen and Smith – like the authors of this special issue – repudiated the fundamental tenets of substance ontology. They rejected the idea that individuated objects or things (substances existing independently of one another) constitute the foundational reality of our world and that causal relations are therefore *external*, i.e., that such relations do not fundamentally alter the nature of the things themselves, only their motions (Kitchener, 1982; Rescher, 1996). Thelen and Smith instead embraced what we would now call a process-ontological conceptualization of dynamics and causality by stressing – again, like the authors of this special issue – the primacy of *internal* relations (Lerner, 1978; Kitchener, 1982). They wrote of a thoroughgoing interdependence among the component activities that constitute a dynamic system, such that the very nature, the very identity, of any given component activity depends upon, and exists by virtue of, that relation of the activity to other component activities comprising the system. They nullified absolutist notions of antecedent and consequent, of cause and effect, by asserting that patterning in dynamic systems is always multiply determined via reciprocity of influence distributed across the component activities of a system (Turvey, Shaw, & Mace, 1978).

In its antimechanistic, process-ontological conception of *causality*, Thelen and Smith's dynamic systems treatment follows directly in the footsteps of classic organicist/systems approaches to development (e.g., von Bertalanffy, 1933, 1968; Weiss, 1939, 1973; Piaget, 1952, 1970, 1985; Reese & Overton, 1970). Yet, in both their 1994 book and subsequent comprehensive treatments, Thelen and Smith (1994, 1998, 2006) took issue with the *organizational* focus of these classic accounts. Specifically, they called into question the organicist/systems tenet that different levels of organizational complexity in systems necessarily inform an understanding of dynamics and therefore constitute important modes of explanation in their own right – from the irreducible organizational qualities, like purposiveness and self-maintenance, that distinguish living from nonliving systems to those, like the capacity for reflection, that distinguish one stage of a living system's development from another (Witherington & Heying, 2015). They argued instead that different levels of organizational complexity in systems constituted little more than epiphenomenal outgrowths of a fundamental process dynamics common to *any* open system, inorganic *or* organic, that exists under conditions far from thermodynamic equilibrium (see Witherington, 2007, 2015 for an extended discussion).

On display in this conceptual clash between Thelen and Smith's dynamics account and its classic systems ancestry is the question of privilege: to what extent, if any, are certain levels of organization in process considered more "real," foundational, or explanatorily valid relative to other levels? In fact, this "issue of what type of process is taken as paramount and paradigmatic" constitutes one of the primary ways in which process ontological frameworks vary with respect to one another, despite being otherwise united by a core set of presuppositions (Rescher, 1996, p. 3). Thelen and Smith's process ontology took as its paradigmatic process organization the here and now, context-specific activities of the most basic of physicochemical open systems – systems for which the emergence and maintenance of spontaneous organization depend on boundary conditions *external* to the system itself and for which no autonomous activity on the part of the system is required to explain its dynamics of spontaneous organization. In so doing, they privileged one level of process organization – that of physicochemical dissipative systems generally construed – over all oth-

ers. By contrast, classic organicist/systems approaches to development largely dispensed with the very idea of privileging one level of process organization over another. Their process ontological frameworks were instead predicated on a layered, multiple-level-of-reality view of nature, beginning with the qualitative divide between living and nonliving process organization and then proceeding to ever more complex levels of qualitatively distinct organization in the development of living systems, all of which were dependent upon but inexplicable in terms of lower levels of process organization (Witherington, 2011, 2015).

Without question, Thelen and Smith critically supplemented classic organicist/systems accounts by applying principles of nonlinear dynamics – mathematically forged in the physical sciences through the study of certain simple, inorganic systems under far-from-equilibrium conditions – to the realm of organic, developmental phenomena. By virtue of conceptual grounding in ceaseless, real-time variability and fluctuation, their dynamics treatment importantly foregrounded "time, process, change, and historicity as among the fundamental categories for understanding the real" in the study of development (Rescher, 1996, pp. 24–25). Yet, in not just backgrounding *but actively renouncing* the organizational focus of classic organicist/systems accounts, Thelen and Smith promulgated a dynamics framework that did more to explain away, rather than to explain, the very qualities that distinguish living, developing systems (Witherington, 2011; Deacon, 2012). Their treatment effectively assimilated the study of developmental dynamics in living systems to the study of change in inorganic, physicochemical dissipative structures like hurricanes and whirlpools. It expressly dissolved any meaningful divide between the organic and the inorganic, and, within living systems, between moment-to-moment behavioral changes and long-term, developmental reorganizations in a system's capacities.

Like Thelen and Smith, the authors whose pioneering dynamics perspectives are represented in this special issue all take as their intellectual heritage the interdisciplinary field of nonlinear dynamics. Unlike Thelen and Smith, however, these same authors also embrace the organizational focus of classic organicist/systems accounts in their conceptualizations of developmental dynamics. As reflected in this special issue, developmental science's current dynamics landscape reveals a set of highly complementary dynamics orientations dedicated to grappling with – rather than trying to explain away – the complexities of process organization that are unique to *living*, *developing* systems. These are dynamics orientations concerned with the phenomena of life and development as specific levels of process organization in their own right, not simply with assimilating living, developing phenomena to general change dynamics in inorganic physicochemical systems. Critically, such dynamics orientations open the doors fully to the world of psychological functioning – to the very questions of purposiveness, end-directedness, normativity, representation, meaning, and subjectivity that mark organisms as unique levels of process organization.

Van Geert's (this issue: see www.karger.com/doi/10.1159/000503825) contribution to this special issue demonstrates how his seminal conceptualization of dynamic systems seamlessly integrates process ontological foci of time, process, change, and historicity *with* thoroughgoing conceptual allegiance to a classic "levels of organization" mind-set – and to the explanatory significance that different levels of organization bring to bear on an understanding of process. As such, his treatment of dynamic systems wholly circumvents the reductionism to which Thelen and Smith's treatment can easily fall victim. Instead, van Geert establishes precisely the sort of breadth and

inclusivity that is necessary for embracing both commonality and qualitative difference in the organizational ranks of such systems, from the inorganic to the organic. Both Bickhard (this issue: see www.karger.com/doi/10.1159/000503826) and Di Paolo (this issue: see www.karger.com/doi/10.1159/000503827) specifically ground their respective dynamics orientations in the organizational integrity and capacity for development that constitutes living systems *qua* living systems. Bickhard critically enumerates different forms of complexity in self-organizing processes before examining how the dynamics of recursively self-maintenance systems – those that actively generate the very boundary conditions required for creation and maintenance of their own self-organization – set the stage for emergent autonomy, normativity, and developmental phenomena of increasing complexity and reflective abstraction in living systems. Di Paolo similarly targets questions of normativity and the vital "autonomous unity" that constitutes living bodies as agents with concerns, needs, and cares before elaborating his enactive account of how sensorimotor agency developmentally emerges from organic agency, modeled in terms of Piagetian equilibration dynamics.

Of the four perspectives represented in this special issue, Adolph's (this issue: see www.karger.com/doi/10.1159/000503823) dynamics orientation, with its instrumental, problem-solving focus on organisms' real-time adaptations to the exigencies of local contexts, bears the most similarity to Thelen and Smith's treatment. Adolph, however, effectively sidesteps the reductionism of Thelen and Smith's account by highlighting her focus as just that – a focus, not a "grand theory." She specifically focuses on what she calls learning *in* development, but without reducing the latter to the former. Critically, Adolph conceptualizes the real-time, adaptive efforts of organisms in context *as nested within*, and necessarily informed by, a broader context of developmental changes which themselves alter an organism's *possibilities* for action and involve the emergence of new skills and abilities in the organism's repertoire. Consequently, unlike Thelen and Smith's treatment and consistent with the other dynamics orientations represented in this special issue, Adolph's ecological approach avoids reducing organization to adaptation and the organism to a collection of local acts of problem solving.

Front and center in all of these accounts is an appreciation of organisms *as integrated wholes,* actively maintaining (and developing increasing complexity in) their organizational integrity through constant commerce (i.e., exchange of matter and energy) with their worlds. By virtue of their allegiance to such an organicist/systems focus, the authors of this special issue readily acknowledge that systematically modeling what organisms actually do under various contextual circumstances is insufficient to adequately capture a full understanding of those dynamics. To fully understand organisms and their dynamics, an organism's activities in context must always themselves be contextualized within an understanding of what the organism, at any given point in its development, *can* and *cannot* do, by virtue of its organization. In other words, any conceptual model of dynamics in those systems that recursively self-maintain their organization necessitates the introduction of a system's capacities or *powers* for action (i.e., the system's abilities, skills, etc.) into its explanatory framework. Across the contributions to this special issue, notions like ability, skill, capacity, and power are, in fact, routinely employed, especially in the context of discussing what kind of organization emerges in living systems at the timescale of development. Discussions of agency, goal-directedness, future orientations/anticipations and virtual conditions are likewise commonplace across the contributions, indicating that any conceptual model of organismic dynamics must be organized "with respect to the vast absential

world of possible future events and abstract properties" (Deacon, 2012, p. 41). The dynamics of inorganic systems require no such organizational consideration.

The conceptual presence, in the dynamics orientations of this special issue, of a system's powers – what it is capable of doing and refraining from doing, as distinguished from what the system is actually doing at any given point in time – is especially noteworthy, given its conspicuous absence from many dynamic systems treatments. Because a system's powers constitute its *potential* for engaging in (or refraining from) activity, not its actual activity, such powers do not constitute material or energetic *presences*. This proves problematic for any model of dynamics that limits itself to a "necessary grounding in what is physically here and now" (Hacker, 2007; Deacon, 2012, p. 5). As Deacon (2012) has cogently argued:

> Dynamical systems theories… implicitly assume that all causally relevant phenomena must be instantiated by some material substrate or energetic difference… absential features must, by definition, be treated as epiphenomenal glosses that need to be reduced to specific physical substrates or else be excluded from the analysis. The realm that includes what is merely represented, what-might-be, what-could-have-been, what-it-feels-like, or is-good-for, presumably can be of no physical relevance (p. 5).

Refreshingly, the dynamics orientations of this special issue seem to actively embrace the powers of living systems within their explanatory frameworks, exemplified not just in their general appeals to powers but in specific appeals to what Deacon has termed *ententional* phenomena, such as purposiveness, normativity, and representation (not in the correspondence sense but in the "future oriented indications or anticipations" sense – see Bickhard (this issue).

However, as treatments of developmental dynamics advance under the auspices of this more organizationally rich conceptual framework, it behooves the field to explicitly consider the question of what exactly is entailed, causally and explanatorily, by appeals to an organism's power. Such a need also extends to the critical question of how phenomena that develop at different timescales influence one another. In what follows, we address both of these critical questions with the hope of facilitating future conceptual advances in developmental science's current dynamics landscape.

Powers and Dynamics

Generally speaking, powers are the potential of an agent, object, etc. to act, to refrain from acting, or to be acted upon (as well as react to being acted upon). Appeals to powers in the causal understanding of activity trace most prominently to Aristotle, as well as to Thomistic extensions of Aristotelian thought. In recent years, renewed appreciation for the explanatory significance of powers has resurfaced within various circles of philosophical inquiry (including philosophy of science and philosophy of mind), inspiring new Aristotelian- and Thomistic-influenced frameworks (e.g., Ellis, 2002; Hacker, 2007, 2013; Marmodoro, 2010; Groff & Greco, 2013). However, to the extent that Aristotelian thought espouses an ontology of substance[1], an immediate

[1] See Rescher (1996) for a discussion of both the substance and process ontological facets of Aristotle's philosophy. As Rescher argued, "while Aristotle's metaphysics of substances and natural kinds was an emphatic substantialism, Aristotle's metaphysics nonetheless also deployed a considerable array of processist elements" (p. 11).

challenge arises for any dynamics orientation that looks to incorporate the notion of powers. That challenge involves conceptually framing powers in ways that are compatible with a process ontology (Anjum & Mumford, 2018). Notably, Rescher (1996) readily admits powers into his treatments of process ontology, suggesting that "as far as process philosophy is concerned, things can be conceptualized as clusters of actual and *potential* processes" (p. 46, italics added).

But what exactly does it mean for a power to be a potential? Critically, powers, as potentials, are not actualities. Powers speak neither to the activity of an agent in the world nor to the internal activities or processes that temporally precede that activity in the world. The power of an agent to do something does not constitute an antecedent force that makes agents actually do what they have the power to do. This means that powers are neither processes, activities, substances, materials, nor states; they are neither "owned," "stored" nor "located" anywhere (Kenny, 1975; Hacker, 2007). They instead constitute what agents *can* do. Powers, in other words, reflect the *organization* of a system – an organization that, in the case of living systems, is dynamically maintained under far-from-equilibrium conditions for periods of time and across context (such as during periods of stability in development). Powers capture the potential for functioning of systems *qua* systems, as integrated wholes, abstracted from the spatiotemporal particulars of a system's activities in multitudes of contexts.

Clearly, powers invoke modes of explanation fundamentally different from traditional, material, antecedent-consequent notions of cause. Specifically, they invoke organizational modes of explanation, following in the general tradition of Aristotelian formal and final causes (Rychlak, 1988; Juarrero, 1999). As organizational modes of explanation, powers constitute *constraints*. They refer to *limitations* on what kinds of activities are available to the agent. They represent the degrees of freedom within which an agent can operate, the bounded range of possibilities available to a system for various kinds of activities (Juarrero, 1999; Deacon, 2012). As such, powers carry critical explanatory weight. They provide a crucial explanatory frame – namely that of the agent *qua* agent, organized across time and context – within which to understand the actual activities of an agent in particular context. The meaning of any given action on the part of an agent, as well as the implications of that action for an agent's subsequent actions, necessarily depend on what that agent, in general, is currently capable of doing, as well as on what that agent is currently *not* capable of doing. Necessarily, an agent's powers are *irreducible* to the exercise, or actualization, of those powers (i.e., to the actual activities-in-context in which the agent engages). Any given power can be exercised through various actions, and any particular action may be associated with the exercise of different powers. Powers need never be exercised in the lifetime of an agent, and an agent's happening to engage in a particular activity does not mean that the agent has the power for such activity, since the isolated activity could simply be a fluke (Hacker, 2007; Witherington, 2019).

What this all illustrates is that the relation between powers and their exercise is properly conceptualized in *logical*, not causal terms (Kenny, 1975; Hacker, 2007). Unfortunately, notions of power have long been the subject of conceptual confusion in the philosophical literature (Ayers, 1968; Hacker, 2007). All too often, conceptual treatments end up reifying powers by mischaracterizing them as things, activities or processes that reside inside the agent and that causally initiate the agent's outer activity or behavior. Alternatively, many conceptual treatments end up rejecting the conceptual utility of powers altogether on the grounds that powers are nothing but their

exercise. Such efforts at reductionism render the notion of power itself as explanatorily superfluous (Hacker, 2007). Both of these conceptual confusions are united, however, in mistakenly presupposing that powers, to be explanatorily meaningful, must bear a causal, antecedent-consequent relation to their exercise. The challenge for dynamics orientations seeking to rehabilitate the explanatory viability of power rests in avoiding these conceptual confusions and, in the process, embracing organizational modes of explanation.

Reification of powers is ubiquitous in developmental science (and in psychological science generally), as the proliferation of competence-performance and information processing models in the study of cognitive development attests. What rightly should be conceptualized as powers – as potentials for activity – in these models becomes instead internal control structures or instruction-filled homunculi (competences) that temporally precede and guide the production of external behavior or "performance." In the world of dynamics orientations, Thelen and Smith (1994, 1998, 2006) leveled important and highly influential criticisms against such models. Given that reified notions of competence cannot readily account for the enormous context-dependent variability in an individual's responding to any given task and that no reasonable account exists for how these internal control structures manage to actually motivate real, physical activity in the real, physical world, Thelen and Smith argued that appeals to such internal structures are explanatorily vacuous. But in rightly rejecting the conceptual confusion of reification evident in these models, Thelen and Smith managed to promulgate another conceptual confusion by regarding *all* explanatory appeals to ability, capacity, power, etc. as cases of reification. This stemmed from Thelen and Smith's ontological insistence that concrete grounding in temporally based, distributed causal processes – in the real-time dynamics of organisms in context – constitutes the only viable form of explanation for what organisms do (Witherington, 2007, 2015). Thus, despite their critical repudiation of reified notions of power, Thelen and Smith ultimately defaulted in their dynamics orientation to a reductionist treatment of powers, in which powers were nothing but their exercise.

Over the last 40 years, Fischer and colleagues have elaborated a *dynamic skill* framework that holds promise for integrating powers into the study of developmental dynamics without succumbing to conceptual confusions of either reification or reductionism (e.g., Fischer, 1980; Fischer & Bidell, 1998; Mascolo & Fischer, 2015). In their framework, skills constitute capacities to act and would thus seem to resemble the notion of powers as potentials. Critically, however, Fischer and Bidell (1998) have rendered their notion of skills in context-specific terms, arguing that "people don't have abstract, general skills" and that "skills are always skills for some specific context of activity" (p. 478). It would seem that Fischer and colleagues' notion of skills serves to specifically account for variability in an organism's task-specific activity rather than as an organizational abstraction from the particulars of activity in context. As a result, ambiguity surrounds what exactly skills entail relative to their exercise or whether skills are, in fact, distinct from their exercise. Are skills potentials to act and not actualities in themselves by the dynamic skills framework? If skills are potentials to act and are irreducible to their exercise, then why do dynamic skills theorists insist on rendering skills in context-specific terms? Part of what adds to this ambiguity is the tendency of so many dynamics orientations to render all reality in terms of process – and therefore in terms of temporally and contextually-situated activity – *without* fully embracing the qualifications that all process is necessarily organized and that

organization is explanatory in its own right (Rescher, 1996; Overton, 1998, 2015; Bickhard, 2008). Powers reflect the organization side of all levels of organization in process.

Cataloguing stability and transformation in organismic powers across developmental time was a central, if not *the* central, focus of the process ontology and research enterprise of classic organicist/systems theorists, instantiated perhaps most prominently in the structuralism of Piaget. Yet, conceptual confusions arose even in these classic accounts, despite the clear value that organicist/systems theorists placed on formal levels of explanation and on the explanatory significance of organization (Witherington & Heying, 2015). Inconsistencies, for example, in how Piaget himself characterized psychological structure have long fueled debate between formal and functional readings of his structuralism (Campbell & Bickhard, 1986; Chapman, 1988; Overton, 1991). Schemes, whether sensorimotor or operational, are psychological powers – potentials for action – in formal readings of Piagetian structuralism but become reified, internal activities in their own right – causally initiating external activity – in functionalist readings. Conceptualizing powers and the relation they bear to exercise stands as a critical challenge for dynamics orientations as they advance toward incorporating notions of power into the study of dynamics. That challenge magnifies considerably once powers and their exercise are extended in time, i.e., considered diachronically and not just synchronically. How do transformations that take place at the level of developmental time relate to those that take place at the level of real time?

Timescale Interrelations

Of course, *developmental time* is no less real than *real time*. Perhaps it is better to say that the distinction between real- and developmental-time refers not specifically to a distinction in time or between timescales per se but instead to a distinction between different *aims*. Real time is concerned with the short, concrete, here and now. For some, as reviewed above, this refers to the context-specific activities of the most basic of physicochemical open systems, whereas for others this refers to the adaptive efforts of organisms in context. But although developmental time is usually associated with longer time spans relative to real time, developmental time changes can actually be of any duration. The notion of developmental time always points to the very important idea of sequence and does not refer to time as linear duration per se. Each developmental step builds on previous steps, and whether it takes milliseconds, years, or ages is not crucial. What is essential for developmental time are the ordering and associated increase in organizational complexity, which require time but are not defined by time. Such different levels of organizational complexity are interesting emergent properties according to conceptualizations of developmental dynamics with an organizational focus (exemplified by contributions in this special issue and as discussed above).

Having clarified this, we still have to account for different stages or levels and address the question of how they come about (i.e. the question of emergence). This leaves us with four options or ways to construe the (inter)relation between "real and developmental" time.

Focusing on the Lower Level of Process Organization

Seeking to connect real time changes and characteristics (processes and powers) at a certain point in developmental time to real time changes and characteristics at a later point in developmental time may be not only difficult or nigh impossible, but actually futile, like missing the point of what developmental time is all about. Adolph (this issue) presents ample empirical evidence that learning "does not transfer from earlier to later developing skills. … Learning is no faster for the next skill in development. Infants show separate, parallel learning curves for sitting, crawling, cruising, and walking." Her conclusion is that infants acquire (and have to acquire) behavioral flexibility. Her findings underscore our claim that, more generally, the processes taking place within a developmental stage are not necessarily mimicking the processes in the next (or other) developmental stages (i.e., with the arrival of each new stage, you have to do it all again, meaning that development takes time and is effortful), and that overall trends in normative development are not simply reducible to within-stage processes.

Focusing on the Higher Level of Process Organization

Initially, with the advent of non-linear dynamic systems theory, dynamic explanations of development that were globally representative of developmental time met with some success. Dynamic systems strongly suggest overall trends, due to self-organization (cf. chaos theory and the early work of van Geert, 1994), that involve scale-invariant phenomena, e.g., based in recursiveness. This might explain how levels emerge in developmental time in the first place but affords little insight into the detail of real-time dynamics and offers no way to address learning. "Increasing complexity" in this sense remains a rather empty description. It may have worked in simulation contexts but was not very satisfactory or influential beyond that.

Acknowledging Layered, Multiple Levels of Reality

Closely related to the previous option, nonlinear dynamic systems accounts were heralded as offering explanations of how new stages might emerge, proving the possibility of emergence through reorganizations flagged by discontinuities and hysteresis (van der Maas & Molenaar, 1992). This work brilliantly showed how a transition was, in principle, possible. However, the levels explored were too narrowly defined, and the applicability of such work to empirical research proved overly difficult. A consideration of powers (as discussed above) was also lacking, and efforts to explain how a more complete sequence of stages in development (cf. previous) could come about were not successful.

Connecting the Layered, Multiple Levels of Reality and Privileging None

This option is a renewed effort to model interrelations between timescales but is less formal and mathematical in nature. Long-time developmental changes (from

stage to stage) presume learning and a normative dimension as discussed by Bickhard (this issue). Such development implies emergent properties, at each level of abstraction and organization, that are due (in essential part at least) to interactions among all kinds of lower levels of abstraction and organization and are thus dependent upon, but nonetheless inexplicable in terms of, these lower levels of process organization. However, we require a better understanding of how an emergent novel level can constitute an advance from the previous level. Bickhard (this issue) proposes that the dynamics of recursively self-maintenance systems can help in this regard. Di Paolo (this issue) finds inspiration in Piaget's equilibration theory. Piaget himself also proposed *reflective abstraction* as relevant to addressing these problems (cf. Boom, 2009).

What is needed for conceptual advance is acceptance and clear definition of developmental levels (cf. Spencer, this issue: see www.karger.com/doi/10.1159/000504296). Developmental levels point to patterns or structures as Piaget had it. Such patterns we seek to uncover. They refer to designations of functioning at different points along the scale dimension of developmental time. But such designations can only be characterized in terms of global features (stages, milestones, skill-level, etc.). Although elapsed time (or something in terms of age) is an important index for these levels, the core indices for understanding them are complexity increase and hierarchical integration of some kind. Such indices ultimately need to be explained. Phenomena that develop at different timescales can influence one another, and these are all real (time) phenomena. But more clearly understanding the relation of these phenomena with levels of organization remains a most difficult challenge.

Conclusion

For classic organicist/systems thinkers, the study of a system's dynamics was as much about organization and wholeness as it was about time, change, variability, and historicity (e.g., von Bertalanffy, 1933; Weiss, 1939; Piaget, 1952). If anything, their forays into building a science of dynamics in the early decades of the 20th century were even more focused on the organizational side than on the process side of process organization (von Bertalanffy, 1968). With the resurfacing of dynamics orientations toward the end of the 20th century, consideration of the process side of process organization assumed center stage, ably guided by new mathematical techniques for modeling complex systems dynamics (e.g., Thelen & Smith, 1994; van Geert, 1994). But in the hands of some of the most prominent dynamics thinkers of the time, considerations of organization were not only backgrounded but regarded as explanatorily vacuous and even antithetical to a true appreciation of dynamics (Thelen & Smith, 1994). As the second decade of the 21st century nears its end, dynamics orientations are not only enjoying steadily growing prominence in developmental science but are also forging decidedly integrative approaches that embrace the explanatory significance of *both* sides of process organization. Moving forward with these integrative efforts demands conceptual rigor, and we have endeavored in the epilogue of this special issue to highlight two areas of consideration – notions of powers and of timescale interrelations – worthy of more refined conceptual analysis in current dynamics treatments. Nonetheless, it is clear from this survey of today's dynamics orientations that the study of dynamics in developmental science is more committed than ever to the multi-perspective stance of a "process-relational" paradigm, wherein consider-

ations of the bottom-up dynamics of developmental process go hand in hand with a holistic structuralist emphasis on the explanatory significance of system organization in its own right (Overton, 1998, 2015; Overton & Lerner, 2012). As the clarion call for process ontology spreads across the sciences, the words of Rescher (1996), in his introduction to process metaphysics, bear repeating: "A process involves more than change as such. It is always a matter of *organized* variation – structured change is of the very nature of process" (p. 86).

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