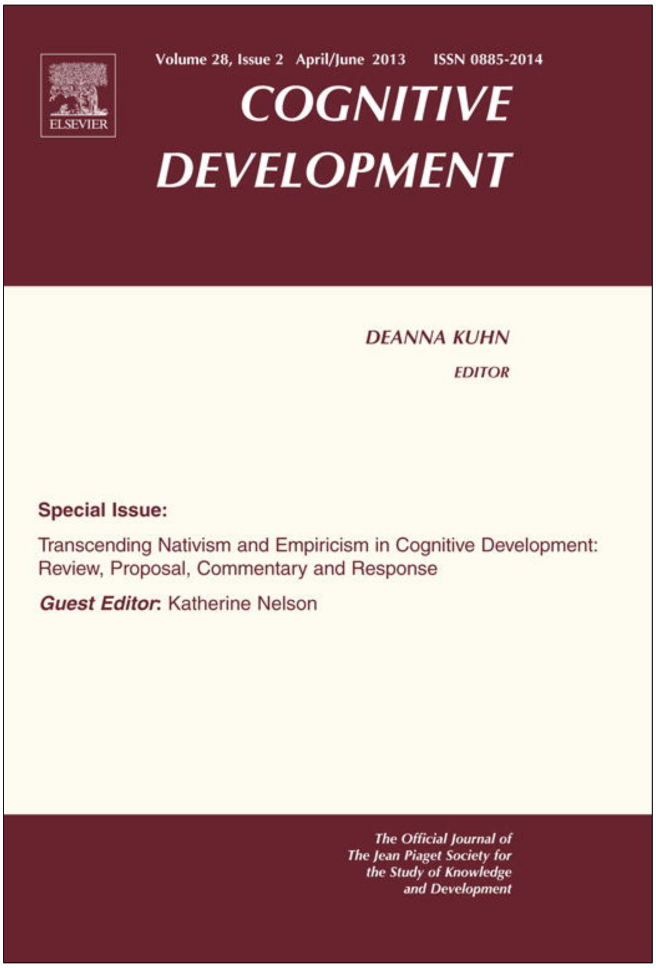
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Commentary

Recognizing transcendence when you see it: Dynamical systems theory as an action-based approach: Commentary on "Stepping off the pendulum: Why only an action-based approach can transcend the nativist–empiricist debate" by J. Allen and M. Bickhard

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In their compelling article, Allen and Bickhard (2013) take a major step toward ending the nature-nurture debate once and for all. They trace the history of the debate, detailing precisely where developmental psychologists moved away from Piagetian constructivism and split into the current nativist and empiricist camps. Allen and Bickhard focus on two bodies of research – Baillargeon's drawbridge studies and Wynn's arithmetic studies – to show how methodologically and theoretically flawed the nativist position is. I applaud the authors for weaving together the many different experimental threads that have challenged the nativist interpretations. While each individual study may appear to be a 'loose thread' in the fabric of nativism, describing them all together is a powerful reminder that many loose threads can and should unravel the entire tapestry.

Allen and Bickhard then offer some theoretical critiques of empiricism, and propose that the field move away from this debate and instead focus on understanding the origins of knowledge through an action-based approach. They claim that their Interactivist Model of Representation is the best approach because it avoids four fundamental problems facing nativism without resorting to empiricism (which suffers from some of those same fundamental problems). These four major issues are: (1) the performance–competence distinction; (2) foundationalism; (3) conflation; and (4) partial/graded knowledge. While I whole-heartedly agree that any theory of development must be able to handle all of these issues, I believe that Dynamical Systems Theory (DST) does just that, without relying on a representational base, while also explaining where new knowledge comes from. Thus, I believe DST is already the viable Action-based approach that the authors seek.

DST rejected the performance–competence distinction nearly two decades ago (Thelen & Smith, 1994). Because DST emphasizes time (e.g., Thelen & Smith, 2006; Van Gelder & Port, 1995), the notion of a core competence that is stable and enduring simply doesn't fit. Instead, mental activity develops from

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perception and action, inextricably linked to both internal and external context. These time-locked interactions cannot be separated or broken down into a fundamental "knowledge" that exists apart from the interactions. Knowledge itself is the memory, attention, movement, decisions, strategies, emotions, and motivation that comprise behavior (Thelen & Smith, 2006).

DST also avoids foundationalism, as Allen and Bickhard (2013) acknowledge. Foundationalism refers to the idea that at the core of both nativism and empiricism lies a representational base. This is problematic for both views because there is no way to explain where that representational base comes from (without resorting to nativism or passing the problem off to biologists) and there is no way to get new (representational) knowledge without that base. DST avoids these problems in the same way that the authors' action-based approach does, by avoiding the concept of knowledge as initially representational. In particular, DST views knowledge as self-organizing processes across multiple levels, ranging from genetics and the cellular level up through an individual's behavior, embedded within a social and historical context (e.g., Spencer, Simmering, Schutte, & Schoner, 2007; Thelen & Smith, 2006). These levels are constantly interacting, and each interaction can initiate cascading effects across all the other levels. The interactions themselves, both internal and external, are the stuff of knowledge. Each decision to behave in a particular way in a particular context then becomes part of the next decision, continuing the cycle of interactions. These ideas are similar to the affordances and interactive web of possibilities that Allen and Bickhard describe.

Similarly, DST avoids conflation, meaning that reactions are possible without knowledge representations driving the reaction. As with the interactivist model, action decisions or anticipations are sensitive to the environment without representing it. This is most fully explored in the Dynamical Field Models applied to the AnotB task, which explore the contributions of timing, perceptual layout, stimulus salience and motor memory to reaching and looking decisions (e.g., Clearfield, Diedrich, Dineva, Smith, & Thelen, 2009; Smith, Thelen, Titzer, & McLin, 1999; Thelen & Schoner, 2006). Both the Dynamical Field Models and Dynamical Systems Theory more generally can likewise capture partial or graded knowledge (e.g., Thelen & Schoner, 2006). Because knowledge is demonstrated by decisions to act, those actions can reveal partial success on a task, or success under some circumstances but not others.

Solving these four challenges is not enough to make a theory of knowledge successful. A successful theory must explain where new knowledge comes from, or, in Allen and Bickhard's words, how new representations are made. This is where the major differences between DST and the Interactivist Approach become clear. Allen and Bickhard both applaud DST for avoiding the above-described challenges by virtue of not being representational, and yet argue that DST's major weakness is that it doesn't explain how knowledge becomes representational. The problem is that whereas in the Interactivist Approach, knowledge is made through action and then becomes representational, in most versions of DST, action makes knowledge, but knowledge never becomes representational (although it can be stable and thereby act representational, see Spencer & Schöner, 2003).

Both theories, DST and the Interactivist Approach, begin at the same place: Piaget's (1952) view of how knowledge is constructed through infants' own actions. For example, when an infant is given a pacifier, she begins reflexive sucking movements. But the movements change the location and feel of the pacifier in her mouth, so the infant adapts her sucking to those changes. These movements also stimulate the infant, so she begins to suck faster on the pacifier, causing it to move even more, and compelling her to adapt her movements to keep the pacifier in an optimal location. She may also be able to see the end of the pacifier moving in response to her movements, which may be visually arousing. This too may cause changes to her sucking movements. Although the sucking pattern may have begun as a reflex, it quickly became goal-oriented and organized. Piaget called this a secondary circular reaction, and he argued that this process of action affecting perception affecting action – that loop – is the very foundation of cognition.

For DST, that perception–action loop is just one of many systems that are coupled together in any given task. For example, an infant in the modern version of Piaget's classic AnotB task is presented with one of two identical objects and asked to reach for one of them. Before the task begins, the infant's visual system is taking in the similarity of the objects, the fact that the objects match the background, and other elements of the perceptual layout (known as the task input, e.g., Thelen, Schoner, Scheier, & Smith, 2001). Infants are asked to reach to one of the objects by an experimenter waving it and capturing infants' attention (this increase in salience is called the specific input). The experimenter then places the target object closer to the infant than the other object for the first 3 trials. This boosts the salience of that location (the A location) in the task input. After a brief delay, the infant is allowed to reach for the object, creating a motor trace or motor memory for reaching to that location. After several trials to that A location, the experimenter then cues the B location and places the B object even with the A object. At that moment, the task inputs are equal in salience. But a competition has arisen between the strong specific input at the B location and the strong memory input for the A location (after several reaches to A). Where the infant will reach depends on these interacting factors: visual input of the task, the salience of the specific input as it decays during the delay, and the strength of the motor memory. Each of these factors can be boosted or damped down by small changes in the task.

The stability of infants' reaches (Clearfield, Smith, Diedrich, & Thelen, 2006), how the objects look when set on the table (Diedrich, Highlands, Thelen, & Smith, 2001), the salience of the cuing event (Clearfield et al., 2009), the delay over which infants need to remember the cue (Clearfield et al., 2009), and interruptions to the motor memory (Smith et al., 1999) all impact infants' decisions of where to reach on that critical first B trial. Over time, through repeated interactions in the world, these systems (visual, motor and memory) become more stable, meaning they are less prone to perturbations and can respond more flexibly. When 12-month-old infants stop making the AnotB error, it may be because their visual memories last longer and their motor memories are flexible enough to change their movements when appropriate.

These early perception–action–memory couplings are the foundation for later behavioral decisions regarding spatial memory for locations. Critically, those couplings are never outgrown. By two years of age, children can remember the location of a hidden toy despite changes to their physical location, if there are external visual landmarks (Newcombe, Huttenlocher, Drummey, & Wiley, 1998). This suggests that stronger visual memories can compensate for perturbations to the motor memory. Manipulating the salience and stability of a landmark can improve spatial memory in 2½-year-olds, even in a difficult task (Perry, Samuelson, & Spencer, 2009). The spatial memory biases that are typical of 3½- to 5-year-olds can be overcome by manipulating the salience of their frame of reference (Schutte & Spencer, 2010). Even adults need salient perceptual support to make spatial category boundaries (Simmering & Spencer, 2007). Thus, later behavioral decisions, even as late as adulthood, are still based on the same perception–action systems that describe early infant behavior.

Critically, it is the coupling of those many different systems to each other and to a task in the world that creates a fantastically complex dynamical system. In other words, each task may involve only a few systems, but those systems have complex components that can couple in different ways across different tasks. And acting in the world involves tasks that rely on overlapping components (e.g., Smith & Sheya, 2010). It is through those multiple overlapping tasks that all the components become coordinated. That dynamical system then "learns on its own, discovers higher-order regularities, and changes the internal properties of the subsystems as well as their connections to each other" (Smith & Sheya, 2010, p. 2). What changes with development is how many and which systems, the stability and flexibility of those systems, and most relevant to the target article, the ability to discover higher-order abstractions.

This is the critical juncture, where DST remains non-representational and the Interactivist Approach does not. Those higher order abstractions may, so to speak, represent the concept of representation that has been so troubling. Higher order abstractions transcend a particular system, modality and task (e.g., Barsalou, 2003; Barsalou et al., 2007; Smith & Sheya, 2010). The abstractions contribute stability, so that one can make appropriate behavioral decisions in the face of changing task dynamics. But those abstractions, what we might call knowledge, are still embedded in those complex interactive processes. There is no point at which the abstraction is divorced from the non-cognitive processes that created it, like perception, action, goal management, reward, affect, social interaction and development (Barsalou et al., 2007).

Allen and Bickhard (2013) posit that this kind of representation is in the eye of the beholder, that the neural or system-wide stabilities that lead to higher order abstractions only do so to the extent that researchers define them as such. They argue that if researchers do conceive of these stabilities as "representing" the world, then new representations are possible; if they do not, then there is no way to ever become representational. However, I respectfully disagree with Allen and Bickhard on this point for two reasons. First, I'm not convinced that classic representations are any less in the eye of the beholder than higher order abstractions or neural stabilities. Since representations are not a physical body, they must be a theoretical construct. Therefore, they exist only when and where theorists posit that they do.

More importantly, I think that the strength of DST is precisely that it is not classically representational, that it never becomes so. Making knowledge representational, even if it begins from non-cognitive processes, eventually divorces it from the non-cognitive processes that created it. This is what the Interactivist Approach proposes, that knowledge is built through action but somehow becomes abstract, and separate from the perception–action loops that made it. Knowledge, according to DST, is never disembodied and it is never static. It is never divorced from the myriad of interacting processes that created it. Indeed, it is truly an Action-Based approach.

Overall, I agree with much of Allen and Bickhard's assessment. I agree that nativism is conceptually flawed. I agree that diagnosing the nature–nurture debate is important in allowing the field to transcend it. And I agree that an Action-based approach is the best approach to understanding the process by which infants both achieve stability in interacting with the world while remaining flexibly adaptive. However, I believe that Dynamical Systems Theory may be the best Action-based approach to date. The sticking point between DST and the Interactivist Approach is the notion of representation. Just as the authors call for transcending the nature–nurture debate, perhaps it is time to transcend antiquated notions of static representations. Only when we embrace a new conception of knowledge, one that is always inextricably linked to the non-cognitive processes that create it, will we truly move developmental science forward.

References

Allen, J. W. P., & Bickhard, M. H. (2013). Stepping off the pendulum: Why only an Action-based approached can transcend the nativist-empiricist debate. *Cognitive Development*, *28*, 96–133.

Barsalou, L. W. (2003). Situated simulation in the human conceptual system. *Language and Cognitive Processes*, *18*, 513–562.

Barsalou, L. W., Breazeal, C., & Smith, L. B. (2007). Cognition as coordinated non-cognition. *Cognitive Processing*, *8*, 79–91.

Clearfield, M. W., Diedrich, F., Dineva, E., Smith, L. B., & Thelen, E. (2009). Cue salience and memory in infant perseverative reaching: Tests of the Dynamic Field Model. *Developmental Science*, *12*(1), 26–40.

Clearfield, M. W., Smith, L. B., Diedrich, F. J., & Thelen, E. (2006). Young infants reach correctly on the A-not-B task: On the development of stability and perseveration. *Infant Behavior and Development*, *29*, 435–444.

Diedrich, F. J., Highlands, T., Thelen, E., & Smith, L. B. (2001). The role of target distinctiveness in infant perseverative search errors. *Journal of Experimental Child Psychology*, *78*, 263–290.

Newcombe, N., Huttenlocher, J., Drummey, A., & Wiley, J. (1998). The development of spatial location coding: place learning and dead reckoning in the second and third years. *Cognitive Development*, *13*, 185–200.

Perry, L. K., Samuelson, L. K., & Spencer, J. P. (2009). Aligning body and world: Stable reference frames improve young children's search for hidden objects. *Journal of Experimental Child Psychology*, *102*(4), 445–455.

Piaget, J. (1952). *The origins of intelligence in children*. Oxford, England: International Universities Press.

Schutte, A. R., & Spencer, J. P. (2010). Filling the gap on developmental change: Tests of a dynamic field theory of spatial cognition. *Journal of Cognition and Development*, *11*(3), 328–355.

Simmering, V. R., & Spencer, J. P. (2007). Carving up space at imaginary joints: Can people mentally impose arbitrary spatial category boundaries? *Journal of Experimental Psychology: Human Perception and Performance*, *33*(4), 871–894.

Smith, L. B., & Sheya, A. (2010). Is cognition enough to explain cognitive development? *Topics in Cognitive Science*, 1–11.

Smith, L. B., Thelen, E., Titzer, R., & McLin, D. (1999). Knowing in the context of acting: The task dynamics of the A not-B error. *Psychological Review*, *106*, 235–260.

Spencer, J. P., & Schöner, G. (2003). Bridging the representational gap in the dynamic systems approach to development. *Developmental Science*, *6*, 392–412.

Spencer, J. P., Simmering, V. R., Schutte, A. R., & Schöner, G. (2007). What does theoretical neuroscience have to offer the study of behavioral development? Insights from a dynamic field theory of spatial cognition. In J. M. Plumert, & J. P. Spencer (Eds.), *The emerging spatial mind* (pp. 320–361). New York, NY, USA: Oxford University Press.

Thelen, E., & Schoner, G. (2006). Using dynamic field theory to rethink infant habituation. *Psychological Review*, *113*(2), 273–299.

Thelen, E., Schoner, G., Scheier, C., & Smith, L. B. (2001). The dynamics of embodiment: A field theory of infant perseverative reaching. *Brain and Behavioral Sciences*, *24*, 1–86.

Thelen, E., & Smith, L. B. (1994). *A dynamical systems approach to the development of cognition and action*. Bradford Books/MIT Press.

Thelen, E., & Smith, L. B., 2006. Dynamic systems theories. In W. Damon (Ed.), R.M. Lerner (Vol. Ed.), *Handbook of child psychology. Vol. 1: Theoretical models of human development* (6th ed., pp. 258–312).

Van Gelder, T., & Port, R. F. (1995). It's about time: An overview of the dynamical approach to cognition. In T. van Gelder, & R. F. Port (Eds.), *Mind as motion: Exploration in the dynamics of cognition* (pp. 1–44). Cambridge, MA: MIT Press.