Profile

Movement Matters: The Contributions of Esther Thelen

Linda B. Smith
Department of Psychology, Indiana University, Bloomington, IN, USA
smith4@indiana.edu

Traditional theories of intelligence and its development concentrated on symbolic reasoning, paying little attention to the body and to the ways intelligence affects and is affected by the physical world. Esther Thelen (1941–2004) was a maverick who argued against that traditional view for the idea that intelligence is both made in and realized through physical *actions* on the world. This once singular position is now known as the *embodiment hypothesis* and has become a major organizing theme in contemporary cognitive science, neuroscience, and development (see, for example, Smith and Gasser 2005).

Thelen, a professor of psychology, first at the University of Missouri and then at Indiana University, was never a traditionalist. She received her BS degree in zoology from the University of Wisconsin and her PhD in biological sciences from the University of Missouri, bringing the methods of whole-organism biology to human infants. Her dissertation focused on patterned movements—movements that repeat themselves over and over in a certain rhythmical way. Her idea, the seed of her later developed dynamics systems theory, was that shifts in the variability of behaviors marked developmental transitions. Initially, behavior is highly variable and disorganized; as it becomes organized, it is often highly controlled and inappropriately perseverative; truly skilled action is *both* stable and adaptively flexible. Building on these ideas, Thelen founded a program of research on motor development that grew to become a major influence in developmental psychology, cognitive science, and physical therapy.

In the course of her career, Thelen wrote over 100 articles, two books, and a monograph on motor development, cognitive development, and developmental process. As a consequence of her field-changing discoveries and theories, she received many of the highest honors the field has to offer, held many national leadership posts, and was continuously funded by the National Institutes of Mental Health since 1987. This profile highlights three of her major ideas.

Emergence

The idea of emergence—the *temporary but coherent* coming into existence of new forms through ongoing processes intrinsic to the system—is fundamental to the idea of dynamic systems. Complex systems composed of very many individual elements embedded within, and open to, a complex environment can exhibit coherent behavior: the parts are coordinated without an executive agent, plan, or program. Rather, the coherence is generated solely in the relationships between the organic components and the constraints and opportunities offered by the environment. Thelen showed how behaviors such as walking and reaching can only be understood as the product of multiple components interacting in the here and now of real-time tasks (see especially Thelen and Ulrich 1991).

Thelen (see especially Thelen 1989) took this idea from the generation of a particular movement pattern and extended it more broadly to the developmental process. Crawling, for example, is a coherent movement pattern that infants use for locomotion when they have sufficient strength and coordination to assume a hands-and-knees posture but are not balanced and strong enough to walk upright. Crawling is a stable behavior for several months. But when infants learn to walk, the crawling pattern becomes destabilized by the patterns of standing and walking. Thelen argued that there is no "program" for crawling assembled in the genes or wired in the nervous system. It self-organizes as a solution to a problem (move across the room), later to be replaced by a more efficient solution. Development is a series of evolving and dissolving patterns of varying dynamic stability rather than an inevitable march toward maturity.

Thought in Action

Traditional cognitivist views partition mental life into three mutually exclusive parts: sense–think–act. The "think" part, concepts, intervenes between perception and action and is characterized as fundamentally different (symbolic, propositional) from those real-time processes. Not so, argued Thelen (see Thelen and Smith 1994). Instead, she envisioned cognition as embedded in, distributed across, and inseparable from the processes of perception and action. One area in which she built her theoretical and empirical case for this embodied view of cognition was in her research on Piaget's object concept—on the hypothesized intervening belief between sensing and acting that objects exist in space and time independent of our own actions on them.

Piaget (1962) measured infants' "object concept" in a simple object-hiding task. It works like this: The experimenter hides a tantalizing toy under a lid at location A. After a delay (typically 3–5 seconds), the infant is allowed to reach and most reach to A and retrieve the toy. This A-location trial is repeated several times. Then, there is the crucial switch trial: the experimenter hides the object at a new location, B. At this point, 8- to 10-month-old infants make a characteristic "error," the so-called A-not-B error. Infants reach not to where they saw the object disappear, but back to A, where they found the object previously. Importantly, infants older than 12 months of age usually search correctly on the crucial B trials. Piaget suggested that this pattern indicated that older infants but not younger ones know that objects can exist independently of their own actions.


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Thelen and colleagues proposed a dynamic systems account of the A-not-B error in the form of a dynamic field model (Smith et al. 1999; Spencer et al. 2001; Thelen et al. 2001; Smith and Thelen 2003). Their approach starts with an analysis of *performance*, with the looking, reaching, and memory events essential to the infant's real-time behavior in the task. The key behaviors are these: The infant *watches* a series of events, the toy being put into a hiding location and then covered with a lid. From this, the infant must formulate a *motor plan* to reach and must *maintain this plan* over the delay. The motor plan, necessary in *any* account of infants' performance in this task *in and of itself*, is a "belief" on the part of the system that objects persist in space and time. In this way, the object concept could be considered to be embedded in—not mediating between—processes of perceiving and acting. In a series of experiments, Thelen and her colleagues (see Thelen et al. 2001; Smith and Thelen 2003) showed that the real-time processes that generate the A not-B error, the decision of where to reach, are tightly and continuously tied to the sensory motor system: to looking, reaching, and remembering. Cognition is situated within the same continuous, time-based, and nonlinear processes as those involved in bodily movement, and in the large-scale processes in the nervous system.

Action is the Source of Developmental Change

Thelen (1994) asked: How can a learner *who does not know what there is to learn* manage to learn anyway? This is a more difficult question than might first appear. The issue is whether one needs to prespecify the learning tasks and the learning goals, whether the baby has to know what needs to be learned in order to learn. Thelen showed us the way out of this quandary by demonstrating how babies can discover *both* the tasks to be learned and the solution to those tasks through exploration. Spontaneous movement creates both tasks and opportunities for learning. One elegant demonstration concerns the study of reaching. Thelen and colleagues (Thelen et al. 1993) tracked the week-by-week development of four babies over a three-month period as they transitioned from not reaching to reaching. Four very different patterns of development were observed. Some babies in the nonreaching period hardly lifted their arms at all, but sat placidly watching the world. Other babies were more high-strung and active, flailing and flapping and always moving. These different babies had to learn to solve very different problems in order to learn to reach out and grasp an object. The flailer would have to learn to become less active, to lower his hands, to bring them into midline. The placid baby would have to learn to be more active, to raise her hands, to lift them up from their usual positions on her side. Each baby did learn, finding a solution that began with exploration of the movement space.

Thelen (1994) used a second experimental task, "infant conjugate reinforcement," to make the same point. In these studies, infants as young as three months are placed on their backs; their ankles are attached by a ribbon to a mobile that is suspended overhead. Infants, *through their own* actions, discover this link. As the infants kick their feet, at first spontaneously, they activate the mobile. Within *a few minutes* they learn the contingency between their foot kicks and the jiggling of the mobile, which presents interesting sights and sounds.

Young mammals—including children—spend a lot of time in behavior with no apparent goal. They move, they jiggle, they run around, they bounce things and throw them, and generally abuse them in ways that seem, to mature minds, to have no good use. Thelen showed us how this sort of behavior is essential to the developmental process.

Conclusion

Movement matters. It is our reason for being—to physically interact in a physical world. According to Thelen, the processes that give rise to motor behavior are also the repository of knowledge and the driver of developmental change. As phenomenon, they also provide the key to the nested dynamics of human development. The processes that make movement happen over multiple time scales. Neural excitation, for example, happens in milliseconds. Reaction times are of the order of hundreds of milliseconds. People learn skills after hours, days, and months of practice. What we call "developmental change"—transitions from crawling to walking—occurs over weeks, months, and years. Thelen studied movement at all these time scales and in doing so she unified time. Traditionally, psychologists have considered action, learning, and development as distinct processes. Thelen (see especially Muchisky et al. 1996) argued and showed us in her work how this conceptualization is wrong. For action, for mind, there is but one dimension of time.[1]

Note

1. In keeping with Esther's efforts to share developmental research with the world, the Esther Thelen Memorial Fund (Esther Thelen Memorial Fund—Indiana University Foundation, c/o IU Psychology Department, 1101 E. 10th St., Bloomington, IN, 47405) has been set up to promote the interaction of scientists, practitioners, parents, and policymakers to discuss how the dynamic view of development Esther championed can make children's lives better.

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