

Introduction to the special issue: why this question and why now?

John P. Spencer¹ and Esther Thelen²

1. Department of Psychology, University of Iowa, USA

2. Department of Psychology, Indiana University, USA

Perhaps uniquely among behavioral scientists, developmental psychologists continually grapple with ‘big issues’. Is development continuous or stage-like? Are the processes that underlie developmental change general or specific to particular domains? What are the sources of the complexities of human behavior? Are the outcomes of development determinate or indeterminate? What is the nature of experience and how does it generate change? How can behavioral studies of change be unified with those of the brain? Can development be understood as a computational process, and if so, of what nature? This theoretical ferment percolates into articles, books, symposia and debates, both formal and informal.

In the mid-1990s, two new contenders weighed in. In 1994, Esther Thelen and Linda Smith published *A dynamic systems approach to the development of cognition and action*. Heavily influenced by the new synergetic approach to motor control, ecological psychology and Gerald Edelman’s *Neural Darwinism*, these authors proposed a radical view of development as fluid, multidetermined, grounded in perception and action, and free of mental ‘structure’ in the conventional sense. Two years later, Jeff Elman, Elizabeth Bates, Mark Johnson, Annette Karmiloff-Smith, Dominic Parisi and Kim Plunkett followed with *Rethinking innateness: A connectionist perspective on development*. Here the inspiration for a new view came from connectionist modeling and from new work on early brain development. The main thrust of this book was to offer connectionist models as both metaphor and existence proof for how complex mental representations could evolve from much simpler precursors, like simple neural networks.

Both books generated considerable interest among developmental psychologists and cognitive scientists. Thus, comparisons were inevitable! Were these really two different, new developmental theories, or were they just two different aspects of a single theoretical view? Given that the two approaches came from very different tradi-

tions – perception/action and dynamics on the one hand, and connectionist modeling, language and brain studies on the other – it was not always easy to see the shared assumptions and differences.

In light of growing uncertainty regarding the status of these two approaches, we organized a symposium for the 2001 Biennial Meeting of the Society for Research in Child Development entitled, ‘Connectionism and Dynamic Systems Theory: Are They Really Different Approaches to Development?’ The purpose of the symposium was to bring together some of the leading proponents of the two views to do some serious work: Could we both illuminate our similarities and acknowledge our differences? Moreover, could we situate these new contenders in the context of a long tradition of developmental theory? What did we share with older theories and how did we differ?

The symposium, like the earlier books, sparked intense discussion, both among the participants and between the speakers and the large audience. Consequently, after several drinks and (ironically enough) an excellent fusion meal, we collectively concluded that it was time to put this down on paper – to more thoroughly probe the assumptions behind the two approaches, and to assess the state of the approaches after more than 5 years since the books were published. This special issue of *Developmental Science* is the result.

At the symposium, Thelen and Bates gave individual presentations, but upon further reflection, they decided that their shared experiences as theorists and modelers-come-lately were best narrated in a single paper. Their paper in this volume provides the backdrop for the ones that follow. These authors relate how, dissatisfied with the current formulations for motor and language development, and committed to a biologically realistic view of development, they embraced the precision and formalisms of dynamic systems theory and connectionism. Thelen and Bates weave a broad tapestry for the special issue by comparing the underlying assumptions of the

new approaches to the assumptions of other contemporary and traditional theories.

John Spencer and Gregor Schöner address a central concern about dynamic systems approaches: their historic emphasis on perception and action, rather than on mental processes. They show how the new dynamic field approach can ‘bridge the representational gap’ while retaining the major advantages of dynamic systems – the ability to account for both stability and flexibility within the same developing system. They illustrate how recent models of the ‘A-not-B’ error can be generalized to older children’s spatial memories and account for developmental changes in spatial categorization. Finally, they lay out key challenges for both approaches: dynamic systems theory must provide a serious account of learning dynamics, and connectionism must embrace the notions of stability and the real-time dynamics of embodied systems.

In the third paper of this volume, Yuko Munakata and Jay McClelland emphasize the importance of connectionist models for understanding developmental change. In particular, they show how these learning networks can simulate the nonlinear nature of developmental trajectories, including the always-puzzling U-shaped curves. An important aspect of connectionist thinking is that of graded representations. On this front, the authors emphasize how graded representations offer new insights into behavioral dissociations and critical periods. Finally, Munakata and McClelland point out how connectionist modeling contributes to our understanding of functional brain specialization.

The commentators bring their own novel perspectives. Jeff Elman, Linda Smith and Larissa Samuelson are ‘insiders’, and Elman and Smith played central roles in the original formulations of connectionism and dynamic systems. But they also have unique insights into both kinds of models. Elman was a core contributor to the *Rethinking innateness* effort. More recently, he has pioneered efforts to understand the dynamics of recurrent networks in order to see how time-dependent changes in these networks actually occur. From his dual vantage point, Elman sees deep similarities between the two approaches and is optimistic about the future. In particular, he sees no reason why each theory cannot handle the immediately pressing future challenges: mental ‘representation’ and learning for dynamic systems, and embodiment and real-time dynamics for connectionism.

Smith and Samuelson have a unique perspective on these two approaches as well. Smith co-authored the dynamics book with Esther Thelen, but both Smith and Samuelson have used connectionist models in their own research. These researchers point out key similarities between connectionism and dynamic systems theory,

including their nature as emergentist approaches and their fundamental break from classic symbol system accounts. Nevertheless, the authors point out that there are useful differences between the two approaches that reflect differences in the *theorists* rather than in-principle differences in the theories. The authors use their own ‘dynamic connectionist approach’ to illustrate how connectionism and dynamic systems theory offer complementary insights into the nature of development and the processes that underlie developmental change. Smith and Samuelson conclude that ‘different is good’ and suggest that proponents of both accounts should be attentive to these differences as they consider the possibility of a unified emergentist theory of development.

The final commentator – Nelson Cowan – takes the perspective of a true ‘outsider’, albeit a sympathetic one. While voicing appreciation for the achievements of these two approaches, and believing they have been highly effective at one level of analysis, Cowan leaves room for symbolic and traditional information-processing approaches. He remains skeptical that a ‘one-theory-fits-all’ approach is realistic. As justification for this view, he notes that neither approach has been especially helpful in understanding the yet unresolved issues of how attention and working memory change with development.

It has been an honor and a pleasure to work with the authors of the articles, the commentators and the reviewers in preparing this special issue. The writing and editing went smoothly and efficiently thanks to Herculean efforts on all fronts. The authors and commentators all wrestled with very challenging material. This effort is reflected in the papers that follow which we think make a unique contribution to the literature. Moreover, the commentators and reviewers worked on a very tight schedule. In particular, a sincere ‘thank you’ to the following reviewers who contributed their time and critical insights: Patricia Bauer, Kurt Fischer, Paul van Geert, Prahlad Gupta, Marc Lewis, Nora Newcombe, Joan Stiles and Michael Thomas.

We hope that these papers will bring the new ideas of connectionism and dynamic systems theory into sharper focus, and that we will inspire more developmentalists to see their usefulness and explanatory power. We view this special issue as an important starting point for what we hope will be a long and fruitful discussion. Although the outcome has yet to be determined, we look forward to the step-by-step unfolding of these two (or one?) theoretical approaches. This is truly an exciting time to be a developmentalist; an exciting time to grapple with the ‘big issues’ of our science.

And with that, we turn to the business at hand: Connectionism and Dynamic Systems Theory – Are these

really different approaches to development? The answer is . . .

References

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