The cognitive and neural sciences have been on the brink of a paradigm shift for over a decade. This book is intended to help galvanize the forces of dynamical systems theory, cognitive and computational neuroscience, connectionism, and ecological psychology that are needed to complete this paradigm shift. The book lays bare the fact that comprehending a spoken sentence, understanding a visual scene, or just thinking about the day's events involves the serial coalescing of different neuronal activation patterns, i.e., a state-space trajectory that flirts with a series of point attractors. As a result, the brain cannot help but spend most of its time instantiating patterns of activity that are in between identifiable mental states rather than in them. The chapters are arranged to present a systematic overview of how perception, cognition, and action are partially overlapping segments of one continuous mental flow, rather than three distinct mental systems. The early chapters provide experiential demonstrations of the gray areas in mental activity that happen in between discretely labeled mental events, as well as geometric visualizations of attractors in state space that make the dynamical-systems framework seem less mathematically abstract. The middle chapters present scores of behavioral and neurophysiological studies that portray the continuous temporal dynamics inherent in categorization, language comprehension, visual perception, as well as attention, action, and reasoning. The final chapters conclude with discussions of what the mind itself must look like if its activity is continuous in time and its contents are distributed in state space.
Eliminativism (or eliminative materialism) has been an important and provocative view in the philosophy of mind since the 1970s. Eliminativism claims that the mental states alluded to in our ordinary talk about the mind – particularly intentional states like beliefs, desires, and thoughts – are the posits of a badly mistaken “folk” theory, and thus, like phlogiston, witches and other posits of badly mistaken theories, they do not exist. This volume is a collection of essays that systematically examine the arguments for eliminativism. Ch. 2 illustrates the way in which connectionist models of belief and memory might be used to support the claim that folk psychology is a radically mistaken theory. Ch. 4 argues against the claim that simulation theory undermines the debate between eliminativists and their opponents. Chs. 3 and 5 argue that the case for the premises of the eliminativist argument is problematic in ways that have not been noted in previous discussions. The long title essay (Ch. 1) argues that, even if the premises are true, they do not support the eliminativist conclusion without the addition of some additional premise, and none of the additional premises that might fill the gap, are defensible. Though many writers rely on the theory of reference to fill the gap between premises and conclusion, it is argued that appeals to the theory of reference cannot do the ontological work required by the eliminativist argument.

In Defense of the Saussurean View of Grammar
Frederick J. Newmeyer

in Possible and Probable Languages: A Generative Perspective on Linguistic Typology
Published in print: 2005 Published Online: September 2007
Publisher: Oxford University Press DOI: 10.1093/acprof:oso/9780199274338.003.0004
Item type: chapter

This chapter argues in favor of the classical Saussurean position with respect to the relationship between knowledge of language and use of language, providing evidence in support of the idea that the mental grammar contributes to language use, but that usage, frequency, and so on are not represented in the grammar itself. The first two sections describe current ‘usage-based models’ and attempt to account for their popularity. The following three sections defend the classical position with arguments based on the compatibility of formal grammar and functional explanation, the failure of connectionism to provide an alternative to formal grammar, and the fact that speakers mentally represent full argument structure. The final sections argue against stochastic
grammars and propose an evolutionary scenario that makes sense of the grammar-use distinction.

Toward a Continuity Psychology
Michael Spivey

in The Continuity of Mind
Published in print: 2006 Published Online: September 2007
Item type: chapter

This chapter outlines the goals of the book: to bring together dynamical systems theory, cognitive and computational neuroscience, connectionism, and ecological psychology to provide an understanding of the mind that is not based on discrete symbols and logical rules. It introduces the concept of a state space embodying all the possible patterns of activation that could, in principle, be exhibited by a group of neurons. Thus, transitioning from one thought (i.e., pattern of neural activation) to another necessarily involves a rather continuous trajectory through that space. This chapter also provides some initial visual depictions and experiential demonstration of this continuous flow in mental activity.

Some Simulation Tools for Tracking Continuous Mental Trajectories
Michael Spivey

in The Continuity of Mind
Published in print: 2006 Published Online: September 2007
Item type: chapter

This chapter promotes quantitative simulation as an important accompaniment to theoretical and experimental methods in dynamical approaches to understanding the mind. A mathematical introduction is provided to some simple dynamical systems, and a variety of recurrent neural network models are discussed. Special attention is paid to a localist attractor network, called “normalized recurrence”, that iteratively integrates probabilistic information and sends recurrent feedback to those information sources, thus modifying their activation pattern based on the evolving averaged bias. Versions of this model are used in a variety of simulations of experimental data in later chapters. The chapter
ends with some discussion of the responsible limitations on a modeling component of any given research program.

**Morphology and psycholinguistics**

Geert Booij

in *The Grammar of Words: An Introduction to Linguistic Morphology*

Published in print: 2007 Published Online: September 2007
Item type: chapter

Psycholinguists study the acquisition of morphological knowledge and the way in which complex words are stored, perceived, and produced. The mental lexicon is a central concept in modelling the storage of complex words in the lexical memory of the speaker. The proper modelling of processing complex words is an important battlefield for competing theories of language perception and production.

**The Nature of Memory Causation**

Sven Bernecker

in *Memory: A Philosophical Study*

Published in print: 2009 Published Online: May 2010
Item type: chapter

This chapter examines the nature of memory causation. This involves identifying the vehicle of memory causation, specifying the strength of the causal relation constitutive of memory, and ruling out deviant causal chains. It is argued that the causal chains connecting the past and present representation must consist in a persisting memory trace. Memory traces are either dispositional beliefs or subdoxastic states. For a memory trace to give rise to a genuine memory it must at least be an INUS condition for one's present state of seeming to remember. If the memory trace is an independently sufficient condition for the state of seeming to remember, it may not be preempted by another independently sufficient condition. The dependence of memory states on past representations must support counterfactuals of the form: if the subject hadn't represented a particular proposition in the past he wouldn't represent it now. This chapter discusses, among other things, the possibility of trace transplants, connectionism, the Gettier problem, hypnosis, and suggestibility.
Combining Connectionist and Dynamic Systems Principles in Models of Development: The Case of Analogical Completion

Denis Mareschal, Robert Leech, and Richard P. Cooper

in Toward a Unified Theory of Development Connectionism and Dynamic System Theory Re-Consider

Published in print: 2009 Published Online: September 2009
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DOI: 10.1093/acprof:oso/9780195300598.003.0010
Item type: chapter

This chapter describes model of the development of simple analogical reasoning and shows how the model accounts for seven characteristics of children's developing abilities to reason analogically. It argues that the model's success is critically dependent upon principles of both connectionism and dynamic systems theory. Thus, the model demonstrates complementarity between the approaches.

Integrating Connectionist Learning and Dynamical Systems Processing: Case Studies in Speech and Lexical Development

Bob McMurray, Jessica S. Horst, Joseph C. Toscano, and Larissa K. Samuelson

in Toward a Unified Theory of Development Connectionism and Dynamic System Theory Re-Consider

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Item type: chapter

This chapter examines the interplay of dynamical systems and connectionism at the level of both theory and computation. It begins with a discussion of developmental mechanism focusing on two particular processes—one typically associated with connectionist approaches and one typically associated with dynamical systems. It then illustrates potential hybrid approaches with case studies from the field of language acquisition. The first—a model of speech category learning—illustrates how a dynamical systems perspective may inform a classic connectionist mechanism (i.e., statistical learning). The second—a model of early word learning—combines connectionist and dynamical systems principles. Both suggest that we can no longer treat these two paradigms as independent.
This chapter argues that connectionist and dynamic systems models complement each other and collectively move toward a unified theory of development if they subscribe to the second view of mechanism—one that treats behavior as soft assembled in the immediate context. The chapter is organized as follows. It first addresses why models aimed at reducing behavior to cognitive components cannot make clear headway. The argument is that a reduction of behavior requires human performance to be relatively context free. However, it is shown with the example of balance task performance that human performance is highly context dependent, even in the sterile laboratory context of balance experiments. The chapter then elaborates on what such context dependence could mean. The chapter reviews more pointed evidence for soft assembly and discusses why models that take soft assembly seriously—connectionist or dynamic systems—anticipate the unified theory.

Are Dynamic Systems and Connectionist Approaches an Alternative to Good Old-Fashioned Cognitive Development?

Lisa M. Oakes, Nora S. Newcombe, and Jodie M. Plumert

This chapter addresses the question of whether dynamic systems and connectionist approaches are an alternative to good old-fashioned cognitive development (GOFCD). The chapter is organized as follows. The first section discusses what connectionism and dynamic systems bring to the study of cognitive development. The second section examines how connectionist and dynamic systems theories relate to other GOFCD theories of developmental change. The third section evaluates the contribution of connectionism and dynamic systems in more depth by
examining explanations of two historically important issues in cognitive development: infants' behavior in the A-not-B task and children's solutions to the balance scale problem. Finally, the chapter considers how well connectionist and dynamic systems approaches address criticisms often leveled at other theories of cognitive development.

A Developmental Systems Theory Perspective on Psychological Change
Timothy D. Johnston and Robert Lickliter

This chapter draws attention to some aspects of development that are considered underrepresented in both dynamic systems theory (DST) and connectionism. The approach taken is that of developmental systems theory, which shares with DST a focus on the whole organism in its environment, and with connectionism a focus on the biological support for psychological change. It adds to those perspectives, a concern with more levels of biological analysis (including genetics), the incorporation of comparative, animal-based research, and attention to evolutionary considerations in the analysis of psychological change.

Transitions in Cognitive Development: Prospects and Limitations of a Neural Dynamic Approach
Han L. J. van der Maas and Maartje E. J. Raijmakers

This chapter discusses old-fashioned cognitive development from the point of view of two modern approaches, connectionism and nonlinear dynamical systems theory. The main assertion in both connectionist and dynamic systems approaches is that higher cognitive functioning is largely based on nonsymbolic, graded, and dynamic properties, of which these same approaches provide the best account. The chapter argues that the claim concerning nonsymbolic higher order cognition is
overstated and explains its position by focusing on sudden transitions in
cognitive development.

Dynamic Systems and the Quest for Individual-Based Models of
Change and Development
Paul van Geert and Kurt W. Fischer

This chapter discusses the question of how dynamic systems theory
can be fruitfully applied to the development of the kind of phenomena
and variables that have been of interest for a long time. Examples of
these phenomena are (a) the development of language, including the
development of the lexicon and syntactic and grammatical knowledge
and skill; (b) the development of cognition and thinking, including
the emergence and acquisition of cognitive skills and knowledge in
various domains; (c) the development of reflective judgment, including
metacognition and social understanding; and (d) the development
of social skills and behavior. Behind all these phenomena are the
development of context-specific but overarching principles of skill
formation, such as principles of relationships, systems of relationships,
and so on.

Dynamic and Connectionist Approaches to Development:
Toward a Future of Mutually Beneficial Coevolution
Michael S. C. Thomas, James L. McClelland, Fiona M. Richardson, Anna C.
Schapiro, and Frank D. Baughman

A tension has existed between connectionism and dynamic systems
theory (DST), and this chapter considers why this should be the case.
The chapter argues that much of the tension arises from a tenet that
the two approaches share: they both rely on the explicit, quantitative
instantiation of ideas in mathematical or computational models. The
use of such models is responsible for much of the theoretical progress generated by connectionism and DST beyond the theories of good old-fashioned cognitive development (GOFCD). But the use of explicit, quantitative models brings with it a new set of problems. The chapter discusses several consequences of the use of such models and considers three points of apparent disagreement between connectionism and DST.

Moving toward a Unified Theory While Valuing the Importance of the Initial Conditions
John P. Spencer, Evelina Dineva, and Gregor Schöner

in Toward a Unified Theory of Development Connectionism and Dynamic System Theory Re-Consider

This chapter seeks to articulate and clarify cases of perceived differences between dynamical systems theory (DST) and the connectionist (CN) approaches that are not real, as well as cases of perceived differences that are real. It discusses the implications of efforts to integrate the two approaches for developmental science more generally. Clarifying similarities/differences between approaches offers far more that just technical clarity for co-called modeler types; it offers a vision of a new, integrative, developmental theory.

BEYOND VAPORWARE?
Wendell Wallach and Colin Allen

in Moral Machines: Teaching Robots Right from Wrong

A goal of machine morality is not just to raise many questions but to provide a resource for further development of artificial moral agents. Chapter 9 surveys software that is currently under development for moral decision making by (ro)bots. These experiments utilize a variety of strategies including case-based reasoning or casuistry, deontic logic, connectionism (particularism), and the prima facie duties of W. D. Ross (also related to the principles of biomedical ethics). In addition to agent approaches that focus on the reasoning of one agent, researchers are working with multi-agent environments and with multibots. This
discussion serves as a comprehensive summary of research to date directed at making (ro)bots explicit moral reasoners. These experiments range from ethical advisors in health care to strategies for ensuring that (ro)bot soldiers won't violate international conventions.

The Robot as a New Frontier for Connectionism and Dynamic Systems Theory
Matthew Schlesinger

in Toward a Unified Theory of Development Connectionism and Dynamic System Theory Re-Consider

This chapter provides an optimistic forecast for the future of connectionism and dynamic systems theory (DST). In particular, it focuses on the idea that regardless of how similar or dissimilar connectionism and DST appear to be at this moment in their development, there are numerous signs that hybridization of the two approaches is not only possible, but also has begun to occur. The chapter begins by reviewing three major, crosscutting themes that are shared by connectionism and DST. It then highlights the evidence for an optimistic outlook by describing recent work in the field of adaptive behavior and robotics, which is illustrated by numerous examples of models that blend elements of connectionism and DST. Finally, it returns to the crosscutting themes and elaborates on each in light of the progress that robotics researchers have made toward a hybrid approach.

MERGING TOP-DOWN AND BOTTOM-UP
Wendell Wallach and Colin Allen

in Moral Machines: Teaching Robots Right from Wrong

The topic of this chapter is the application of virtue ethics to the development of artificial moral agents. The difficulties of applying general moral theories in a top-down fashion to artificial moral agents motivate the return to the virtue-based conception of morality that can be traced to Aristotle. Virtues constitute a hybrid between top-down and bottom-up approaches in that the virtues themselves can
be explicitly described, but their acquisition as moral character traits seems essentially to be a bottom-up process. Placing this approach in a computational framework, the chapter discusses the suitability of the kinds of neural network models provided by connectionism for training (ro)bots to distinguish right from wrong.

The Moral Mind
Jonathan Haidt and Craig Joseph

in The Innate Mind, Volume 3: Foundations and the Future

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Item type: chapter

This chapter discusses how morality might be partially innate, meaning organized, to some extent, in advance of experience. It begins by arguing for a broader conception of morality and suggests that most of the discussion of innateness to date has not been about morality per se; it has been about whether the psychology of harm and fairness is innate. Five hypotheses about the origins of moral knowledge and value are considered, and one of them (a form of flexible and generative modularity) is endorsed as being the best candidate. The importance of narrativity in moral functioning is discussed. In some respects, this is another corrective to what is seen as an overemphasis on deductive and calculative conceptions of value and rationality among both philosophers and psychologists. It is shown that a narrative approach to morality fits well with the nativist ‘five foundations’ view developed in the first part of the chapter, and also helps to explain how the intuitive, evolved foundations of morality are elaborated by cultural activity into the complex, diverse moral functioning that mature human beings display.