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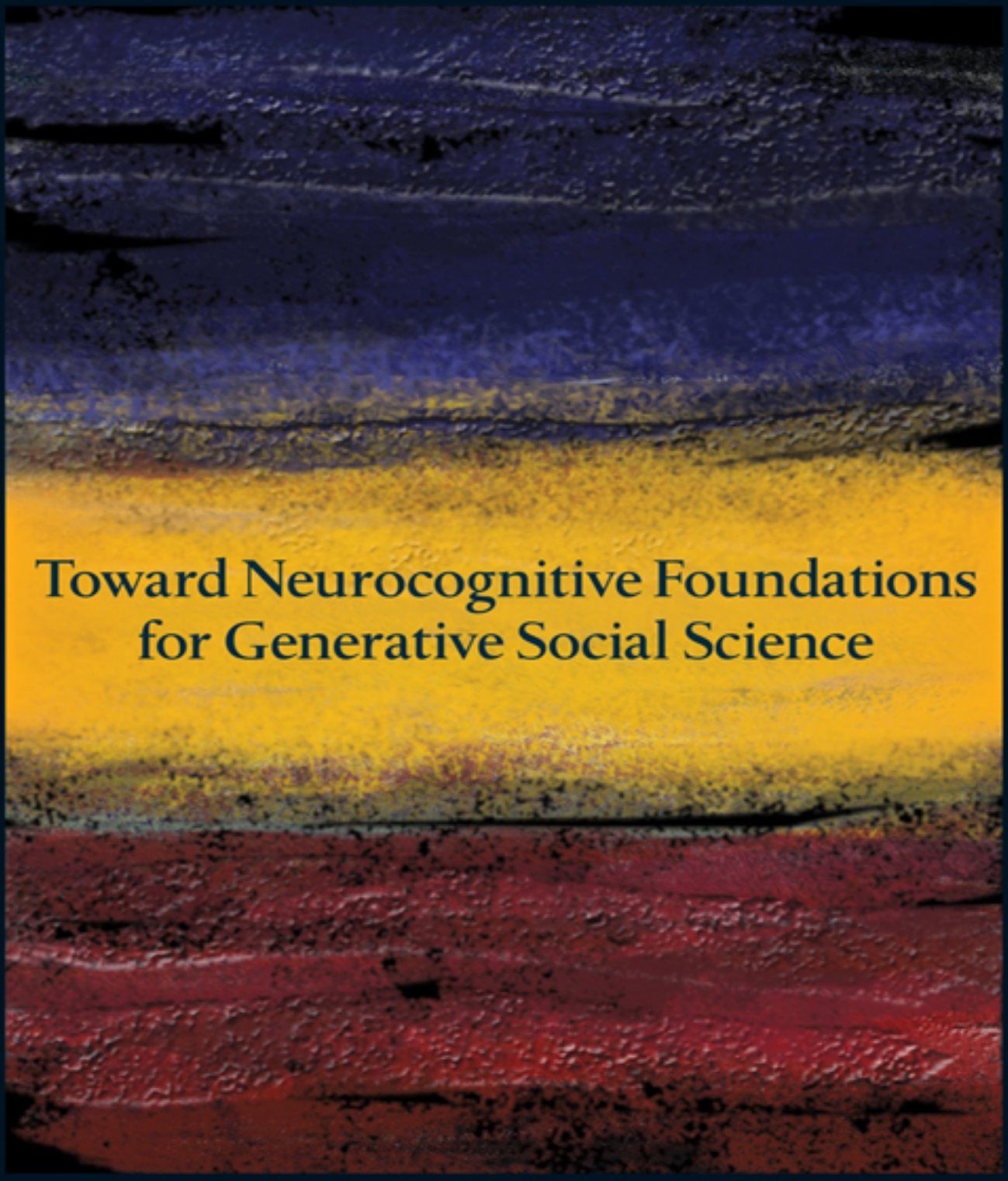

Toward Neurocognitive Foundations for Generative Social Science

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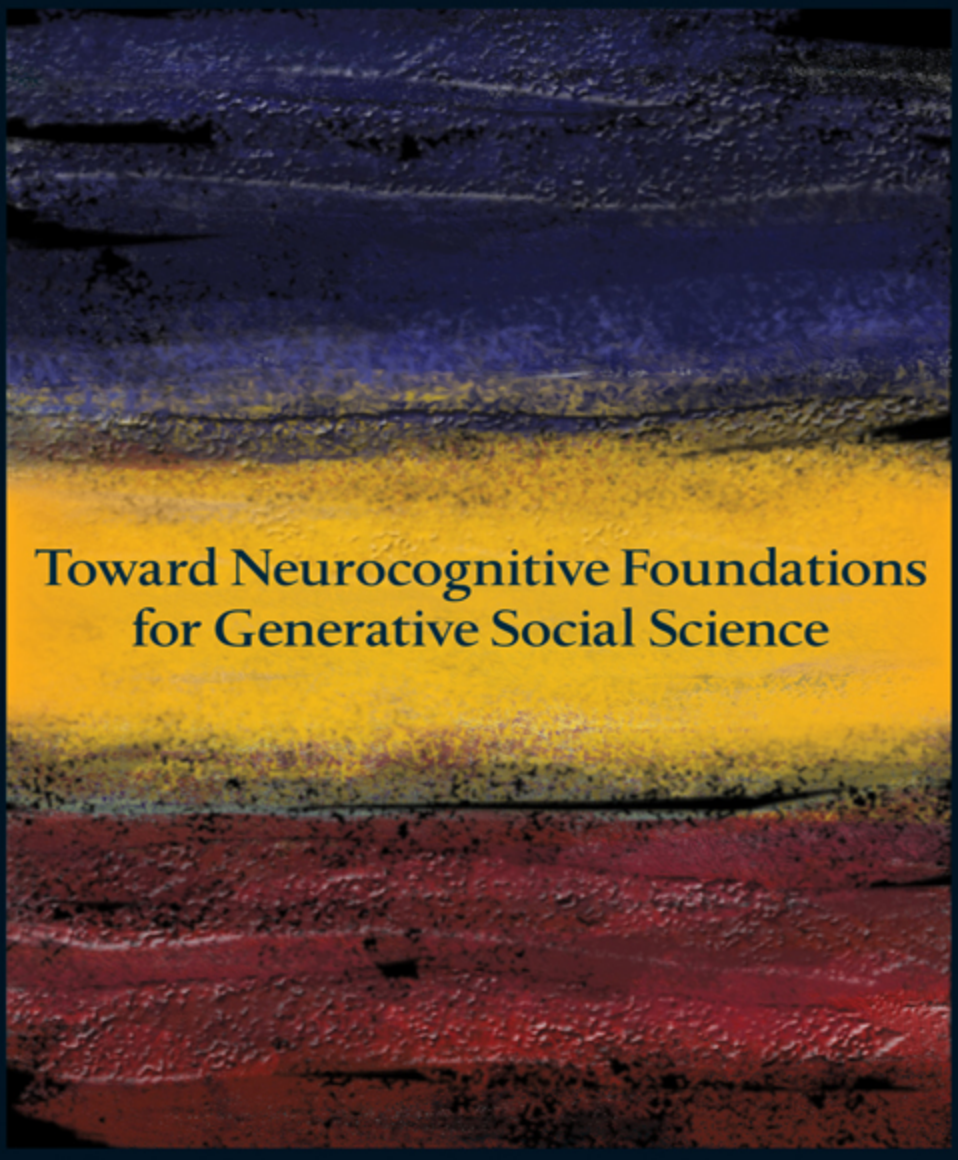

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Agent_Zero

Princeton Studies in Complexity

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Agent_Zero

Toward Neurocognitive Foundations for Generative Social Science

Joshua M. Epstein

Princeton University Press

Princeton and Oxford

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Published by Princeton University Press, 41 William Street, Princeton, New Jersey 08540
In the United Kingdom: Princeton University Press, 6 Oxford Street, Woodstock, Oxfordshire OX20 1TW

press.princeton.edu

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Library of Congress Cataloging-in-Publication Data

Epstein, Joshua M., 1951–
Agent zero : toward neurocognitive foundations for generative social science / Joshua M. Epstein.
pages cm. — (Princeton studies in complexity)
Summary: “The Final Volume of the Groundbreaking Trilogy on Agent-Based Modeling In this pioneering synthesis, Joshua Epstein introduces a new theoretical entity: Agent Zero. This software individual, or “agent,” is endowed with distinct emotional/affective, cognitive/deliberative, and social modules. Grounded in contemporary neuroscience, these internal components interact to generate observed, often far-from-rational, individual behavior. When multiple agents of this new type move and interact spatially, they collectively generate an astonishing range of dynamics spanning the fields of social conflict, psychology, public health, law, network science, and economics. Epstein weaves a computational tapestry with threads from Plato, Hume, Darwin, Pavlov, Smith, Tolstoy, Marx, James, and Dostoevsky, among others. This transformative synthesis of social philosophy, cognitive neuroscience, and agent-based modeling will fascinate scholars and students of every stripe. Epstein’s computer programs are provided in the book or on its Princeton University Press website, along with movies of his “computational parables.” Agent Zero is a signal departure in what it includes (e.g., a new synthesis of neurally grounded internal modules), what it eschews (e.g., standard behavioral imitation), the phenomena it generates (from genocide to financial panic), and the modeling arsenal it offers the scientific community. For generative social science, Agent Zero presents a groundbreaking vision and the tools to realize it”—Provided by publisher.
Includes bibliographical references and index.
ISBN 978-0-691-15888-4 (hardback)
1. Social sciences—Computer simulation. 2. Social sciences—Mathematical models. I. Title.
H61.3.E6697 2013
300.1—dc23 2013018009

British Library Cataloging-in-Publication Data is available

The research for this book was funded by a 2008 NIH Director's Pioneer Award

This book has been composed in Minion Pro and Fairfield

Printed on acid-free paper. ∞

Printed in the United States of America

1 3 5 7 9 10 8 6 4 2

For Matilda,
My lark at break of day arising …

Contents

Foreword

I SEE THIS BOOK as the third in a trilogy on generative social science.

VOLUME I

The first volume of the trilogy was *Growing Artificial Societies: Social Science from the Bottom Up* (MIT Press/Brookings Press), with coauthor Robert Axtell. Published in 1996, this introduced the *Sugarscape* agent-based model, and the notion of a *generative explanation* of social phenomena. Sugarscape was a single sweeping exploratory artificial society, with glimmerings of a mature generative epistemology.

VOLUME II

For the subsequent decade, with diverse colleagues, I applied agent-based modeling to a broad spectrum of fields—economics, archaeology, conflict, epidemiology, spatial games, and the dynamics of norms—and thought more deeply about the philosophy of agent-based social science. The results are collected in the second volume of the trilogy: *Generative Social Science: Studies in Agent-Based Computational Modeling,* published in 2006 by Princeton University Press. Relative to *Growing Artificial Societies, Generative*

Social Science presented a collection of more tightly focused and specifically explanatory exercises, and a far more extended and mature generative epistemology.

VOLUME III

Generative Social Science ended with a challenge: *Grow Raskolnikov*! By this, I meant agents with more fully developed—and so conflicted—inner lives.[1] In effect, it was a call for greater cognitive realism. The present book is my response. It introduces a new theoretical entity, *Agent_Zero*, whose observable behavior is itself generated by the interaction, indeed conflict, of affective, deliberative, and social components. Passion, reason, and social forces, in other words, are all at play in *Agent_Zero*'s observable behaviors, which span a wide array of fields, including economics, health, conflict, social psychology, and endogenous network dynamics. Needless to say, the relationship between passion and reason within the individual, and the relation of the individual to society, are among the more enduring questions in philosophy. And while I do not claim to resolve them, I do claim to treat them in a new way. A significant volume of contemporary cognitive neuroscience is employed in constructing *Agent_Zero*, whom I offer as a new, neurocognitively grounded, foundation for generative social science—hence the subtitle of this book. However, as is repeated numerous times, I use only selected neuroscience in developing this particular agent model. I do not purport to encompass—much less to advance—any area of neuroscience itself. Indeed, through the good offices of a number of very fine neuroscientists, I may have avoided insulting their fascinating and fast-moving discipline.

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[1]Indeed, the name Raskolnikov is from the Russian, *raskólʲnik*, meaning, roughly, schismatic.

Preface

EMOTIONAL, COGNITIVE, AND SOCIAL FACTORS shape the behavior of individuals in groups and hence shape the emergence of important social dynamics, from genocide to financial panic. I wish to generate such social dynamics "from the bottom up," in social networks of neurocognitively plausible individuals. To this end, I introduce a new theoretical entity, *Agent_Zero*, endowed with interacting emotional/affective, cognitive/deliberative, and social modules. *Agent_Zero*'s affective component is based on the Rescorla-Wagner model of conditioning and extinction, supported by recent science on the neural mechanisms of fear conditioning specifically. The agent's cognitive (deliberative) component reflects well-documented biases and heuristics in the estimation of probabilities (e.g., sample selection bias). Agents belong to social networks, and the social component exhibits contagion effects. But, crucially, it is not observable behavior that is transmitted in this model, but *disposition*. I define this here as an explicit function of (a) the individual's emotion and cognition ("passion and reason"), and (b) others' affective and deliberative states. Action is binary and is triggered when individual disposition exceeds threshold. These thresholds, and susceptibility to dispositional contagion, can be heterogeneous across agents, all of whom can exhibit emotional inertia and memory of events. The same basic model, interpreted and extended variously, is shown to generate core phenomena in the fields of social conflict, psychology, public health, law, network dynamics,

and economics. Mathematical and spatial agent-based computational versions of the general model are presented.

I believe *Agent_Zero* to be a departure in what it includes (e.g., neurally grounded internal modules), what it excludes (e.g., standard behavioral imitation), the range of phenomena it generates, and the set of tools it offers the field. Overall, I submit *Agent_Zero* as a step toward unified—and neurocognitively grounded—foundations for generative social science.