

OUTPUT-DRIVEN PHONOLOGY

This book presents the theory of output-driven maps and provides a fresh perspective on the extent to which phonologies can be characterized in terms of restrictions on outputs. Closely related to traditional conceptions of process opacity, but differing in notable ways, the theory of output-driven maps applies equally to SPE-style ordered rules, Optimality Theory, and other phonological theories. It permits a formally rigorous analysis of the issues in Optimality Theory that is not possible with traditional process opacity.

Also presented is a theory of phonological learning. Building on prior work on learning in Optimality Theory, the learning theory exploits the formal structure of output-driven maps to achieve learning that is far more computationally efficient than comparable prior approaches.

In this book Bruce Tesar, one of the founders of the study of learnability in Optimality Theory, presents fresh perspectives in an accessible way for graduate students and academic researchers.

BRUCE TESAR is Associate Professor in the Department of Linguistics and the Center for Cognitive Science at Rutgers University, New Brunswick.



CAMBRIDGE STUDIES IN LINGUISTICS

General editors: P. Austin, J. Bresnan, B. Comrie,

- S. CRAIN, W. DRESSLER, C. J. EWEN, R. LASS,
- D. LIGHTFOOT, K. RICE, I. ROBERTS,
- S. ROMAINE, N. V. SMITH

Output-Driven Phonology: Theory and Learning



In this series

- 106 SHARON INKELAS and CHERYL ZOLL: Reduplication: doubling in morphology
- 107 SUSAN EDWARDS: Fluent aphasia
- 108 BARBARA DANCYGIER and EVE SWEETSER: Mental spaces in grammar: conditional constructions
- 109 HEW BAERMAN, DUNSTAN BROWN and GREVILLE G. CORBETT: The syntax-morphology interface: a study of syncretism
- 110 MARCUS TOMALIN: Linguistics and the formal sciences: the origins of generative grammar
- III SAMUEL D. EPSTEIN and T. DANIEL SEELY: Derivations in minimalism
- 112 PAUL DE LACY: Markedness: reduction and preservation in phonology
- 113 YEHUDA N. FALK: Subjects and their properties
- 114 P. H. MATTHEWS: Syntactic relations: a critical survey
- 115 MARK C. BAKER: The syntax of agreement and concord
- 116 GILLIAN CATRIONA RAMCHAND: Verb meaning and the lexicon: a first phase syntax
- 117 PIETER MUYSKEN: Functional categories
- 118 JUAN URIAGEREKA: Syntactic anchors: on semantic structuring
- II9 D. ROBERT LADD: Intonational phonology second edition
- 120 LEONARD H. BABBY: The syntax of argument structure
- 121 B. ELAN DRESHER: The contrastive hierarchy in phonology
- 122 DAVID ADGER, DANIEL HARBOUR and LAUREL J. WATKINS: Mirrors and microparameters: phrase structure beyond free word order
- 123 NIINA NING ZHANG: Coordination in syntax
- 124 NEIL SMITH: Acquiring phonology
- 125 NINA TOPINTZI: Onsets: suprasegmental and prosodic behaviour
- 126 CEDRIC BOECKX, NORBERT HORNSTEIN and JAIRO NUNES: Control as movement
- 127 MICHAEL ISRAEL: The grammar of polarity: pragmatics, sensitivity, and the logic of scales
- 128 M. RITA MANZINI and LEONARDO M. SAVOIA: Grammatical categories: variation in romance languages
- 129 BARBARA CITKO: Symmetry in syntax: merge, move and labels
- 130 RACHEL WALKER: Vowel patterns in language
- 131 MARY DALRYMPLE and IRINA NIKOLAEVA: Objects and information structure
- 132 JERROLD M. SADOCK: The modular architecture of grammar
- 133 DUNSTAN BROWN and ANDREW HIPPISLEY: Network morphology: a defaults-based theory of word structure
- 134 BETTELOU LOS, CORRIEN BLOM, GEERT BOOIJ, MARION ELENBAAS and ANS VAN KEMENADE: Morphosyntactic change: a comparative study of particles and prefixes
- 135 STEPHEN CRAIN: The Emergence of Meaning
- 136 HUBERT HAIDER: Symmetry Breaking in Syntax
- 137 JOSÉ A. CAMACHO: Null Subjects
- 138 GREGORY STUMP and RAPHAEL A. FINKEL: Morphological Typology: From Word to Paradigm
- 139 BRUCE TESAR: Output-Driven Phonology: Theory and Learning

Earlier issues not listed are also available





OUTPUT-DRIVEN PHONOLOGY

THEORY AND LEARNING

BRUCE TESAR

Rutgers University, New Brunswick.





CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Published in the United States of America by Cambridge University Press, New York

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107001930

© Bruce Tesar 2014

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2014

Printed in the United Kingdom by Clays, St Ives plc

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication data

Tesar, Bruce.

Output-driven phonology : theory and learning / Bruce Tesar, Rutgers University, New Brunswick.

pages cm. – (Cambridge studies in linguistics)

Includes bibliographical references and index.

ISBN 978-1-107-00193-0 (hardback)

1. Grammar, Comparative and general – Phonology. 2. Optimality theory

(Linguistics) 3. Language acquisition. I. Title.

P158.42.T49 2013

414 - dc23 2013020376

ISBN 978-1-107-00193-0 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Every effort has been made to secure the necessary permissions to reproduce copyright material in this work, though in some cases it has proved impossible to trace or contact copyright holders. If any omissions are brought to our notice, we will be happy to include appropriate acknowledgments on reprinting, and/or in any subsequent edition.



This book is dedicated to Heidi and Amanda, for all they have done to inspire my work and my life.

"Who do we ask for help when we don't know which way to go? The map!"

Dora the Explorer





Contents

	List of figures	<i>page</i> xvii
	Acknowledgments	xix
1	Characterizing surface orientedness in phonology	1
1.1	Surface orientedness	1
	1.1.1 Surface orientedness in phonology	1
	1.1.2 Formalizing surface orientedness	3
1.2	Surface orientedness in Optimality Theory	6
	1.2.1 Markedness violations as opacity	7
	1.2.2 Markedness constraints cause disparities	10
	1.2.3 Something more general	11
1.3	Formalizing surface orientedness: output-driven maps	13
1.4	Output drivenness and Optimality Theory	15
1.5	Output drivenness and learning	16
1.6	The relationship between learnability and linguistic theory	18
2	Output-driven maps	20
2.1	The main idea	20
	2.1.1 Terminology: candidates and correspondence	20
	2.1.2 Inputs of greater similarity yield the same output	21
	2.1.3 Unifying surface orientedness	23
2.2	Relative similarity	26
	2.2.1 Relating the disparities of two candidates	26
	2.2.2 Individuating disparities	28
	2.2.3 Relative similarity is a relational notion	30
	2.2.4 The importance of input–output correspondence	33
2.3	Output drivenness is not process opacity	37
	2.3.1 One map, multiple generalizations	37
	2.3.2 Epenthesis and assimilation in Lithuanian	39
	2.3.3 Closeness with processes	42
2.4	Formal analysis with segmental IO correspondence	44

ix



x Contents

	2.4.1	Maps from inputs to candidates	44
	2.4.2	The internal structure of candidates	46
	2.4.3	Relating candidates to each other	48
	2.4.4	The non-uniqueness of input-input correspondence	53
	2.4.5	Removing disparities by changing the input	54
	2.4.6	The identical disparity requirement and surface orientedness	55
	2.4.7	Individuating disparities (again)	57
2.5	Expar	nding to other representational theories	59
	2.5.1	Non-identical corresponding representational elements	59
	2.5.2	Non-unique correspondence	60
	2.5.3	Autosegmental representation	60
2.6	The m	nap	61
3	Outp	out-driven maps in Optimality Theory	63
3.1	_	ground: ERC entailment in Optimality Theory	64
	3.1.1	Elementary ranking conditions	64
	3.1.2	Single ERC entailment: L-retraction and W-extension	66
	3.1.3	Joint ERC entailment: fusion	67
3.2		ng output-driven maps to Optimality Theory	69
J.2		Output-driven maps and optimization	69
		A designated competitor: <i>aoy</i>	70
		Relationships among the disparities	74
		As goes bpy, so goes aoy	78
	3.2.5	Output-driven maps and constraints	81
3.3		ient conditions for output-driven maps	83
	3.3.1	Properties of GEN: correspondence uniformity	84
		•	86
	3.3.3	Proof of sufficient conditions for output-driven maps	87
3.4		constraints: overview of the results	88
J. 1	3.4.1	Terminology: faithfulness and input-referring constraints	88
	3.4.2		89
		Value-independent input-referring constraints	89
		Value-restricted input-referring constraints	90
3.5		raide restricted input referring constaints	91
J.J	3.5.1	The set-up	91
		Deletion disparities	93
	3.5.3	-	94
		Identity disparities	96
	3.5.5	Comments/discussion	101
3.6		at-driven preserving constraints: the proofs	101
5.0	3.6.1	Outline of the proof structure	101
	3.6.2	Max	101
	3.0.2	3.6.2.1 Partition of the deletion disparities	102
		5.0.2.1 Farmon of the defending dispartnes	102



		Contents	xi
	3.6.2.2	Corresponding deletion disparities for <i>aoy</i> and <i>bpy</i>	103
	3.6.2.3	Corresponding deletion disparities for <i>akx</i> and <i>bmx</i>	103
	3.6.2.4	Non-corresponding deletion disparities for <i>aoy</i> and	
		akx	104
	3.6.2.5	$M \land x(bpy) < M \land x(bmx) \text{ entails } M \land x(aoy) <$	
		$M \times (akx)$	104
	3.6.2.6	$M \land x(bpy) = M \land x(bmx) \text{ entails } M \land x(aoy) \le$	
		$M \times (akx)$	105
3.6.3	DEP		105
	3.6.3.1	Partition of the insertion disparities	105
	3.6.3.2	Corresponding insertion disparities for <i>aoy</i> and <i>bpy</i>	106
	3.6.3.3	Corresponding insertion disparities for <i>akx</i> and <i>bmx</i>	106
	3.6.3.4	Non-corresponding insertion disparities for <i>aoy</i> and	
		akx	106
	3.6.3.5	Proof: $Dep(bpy) < Dep(bmx)$ entails $Dep(aoy) <$	
		Dep(akx)	107
	3.6.3.6	Proof: $DEP(bpy) = DEP(bmx)$ entails $DEP(aoy) \le$	
		Dep(akx)	107
3.6.4	Ident	$[F_{in} \in V]$	108
	3.6.4.1	Partition of the identity disparities	108
	3.6.4.2	Identical corresponding identity disparities for <i>aoy</i>	
		and bpy	109
	3.6.4.3	Corresponding identity disparities for <i>akx</i> and <i>bmx</i>	110
	3.6.4.4	Non-Corresponding and non-identical	
		corresponding identity disparities for <i>aoy</i> and <i>akx</i>	110
	3.6.4.5	Proof: IDENT $[F_{in} \in V](bpy) <$	
		IDENT $[F_{in} \in V](bmx)$ entails	
		$IDENT[F_{in} \in V](aoy) < IDENT[F_{in} \in V](akx)$	110
	3.6.4.6	Proof: IDENT $[F_{in} \in V](bpy) =$	
		IDENT $[F_{in} \in V](bmx)$ entails	
		IDENT $[F_{in} \in V](aoy) \leq IDENT[F_{in} \in V](akx)$	111
3.6.5	IDENT	$[F_{\text{out}} \in V]$	112
	3.6.5.1	Partition of the identity disparities	113
	3.6.5.2	Corresponding identity disparities for <i>aoy</i> and <i>bpy</i>	113
	3.6.5.3	Corresponding identity disparities for <i>akx</i> and <i>bmx</i>	114
	3.6.5.4	Non-corresponding identity disparities for <i>aoy</i> and	
		akx	114
	3.6.5.5	Proof: Ident $[F_{out} \in V](bpy) <$	
		IDENT $[F_{out} \in V](bmx)$ entails	
		IDENT $[F_{\text{out}} \in V](aoy) < IDENT[F_{\text{out}} \in V](akx)$	114
	3.6.5.6	Proof: IDENT $[F_{\text{out}} \in V](bpy) =$	
		IDENT $[F_{\text{out}} \in V](bmx)$ entails	
		IDENT[$F_{out} \in V$](aoy) \leq IDENT[$F_{out} \in V$](akx)	115
The m	nap	2 22 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	116

3.7



xii Contents

4	Analy	sis of constraint behavior	117		
4.1	Non-O	DP constraints and non-output-driven maps	117		
4.2	Illustra	ting the three ways of non-ODP	119		
	4.2.1	Distinction only at lesser similarity	119		
	4.2.2	Distinction only at greater similarity	122		
	4.2.3	Distinction conflict	125		
4.3	Relatin	g non-ODP constraint behaviors to non-ODM map patterns	127		
4.4	Faithfu	lness conditioned on output context	129		
	4.4.1	Positional faithfulness I: position-specific DEP	129		
	4.4.2	Positional faithfulness II: position-specific IDENT[F]	132		
	4.4.3	Conjoined markedness and faithfulness	134		
	4.4.4	Value-restricted DEP	137		
	4.4.5	Summary: independent context	138		
4.5	Faithfu	lness conditioned on input context	139		
	4.5.1	Value-restricted MAX	139		
	4.5.2	Relation to output-conditioned faithfulness	142		
4.6	Multip	ly conditioned faithfulness	143		
	4.6.1	Joint input–output value restrictions	143		
	4.6.2	Conditioning on disparities	144		
4.7	Conditioned antifaithfulness				
	4.7.1	Material implication constraints	145		
	4.7.2	$F \rightarrow M$ as output-conditioned antifaithfulness	146		
4.8	Referei	nce to other forms: sympathy	148		
4.9	Eventual idempotency				
	4.9.1	Classical OT grammars are eventually idempotent	151		
	4.9.2	Absolute vs. relative satisfaction of constraints	154		
	4.9.3	Derived environment exchanges	155		
	4.9.4	Absolute vs. relative characterizations of similarity	159		
4.10	The rol	e of relative similarity	161		
	4.10.1	Distinguishing faithfulness from faithfulness constraints	161		
	4.10.2	The rotation theorem isn't about faithfulness	162		
	4.10.3	Relative similarity links grammars to maps	166		
4.11	More o	on relating non-ODP behaviors to non-ODM patterns	167		
4.12	Maps a	and grammars	170		
4.13	The ma	ар	171		
5	Learn	ing phonotactics	173		
5.1		rview of the learning problem	174		
5.2		and length: a system for illustration	175		
5.3	Constructing a constraint hierarchy from winner–loser pairs				
	5.3.1	Recursive Constraint Demotion	177		
	5.3.2	Stratified constraint hierarchies	181		
	5.3.3	Constraint conflict and ranking relations	184		



			Contents	xiii		
5.4	Selecting winner–loser pairs					
	5.4.1	Error de	•	186		
	5.4.2	Product	ion-directed parsing with stratified hierarchies	187		
		5.4.2.1	Mark pooling	188		
		5.4.2.2	Conflicts Tie	191		
		5.4.2.3	Variationist EDCD	194		
	5.4.3	MultiRe	ecursive Constraint Demotion (MRCD)	195		
	5.4.4	MRCD	step by step	197		
		5.4.4.1	First pair	198		
		5.4.4.2	Second pair	198		
		5.4.4.3	Third pair	198		
		5.4.4.4	Fourth pair	199		
		5.4.4.5	Fifth pair	199		
		5.4.4.6	Last pair	200		
	5.4.5	Limitati	ons of loser production via stratified hierarchies	200		
5.5	Assess	sing comp	utational requirements	203		
	5.5.1		nputational complexity of MRCD	203		
	5.5.2	Gramm	ar space vs. language space	205		
5.6	Restrictiveness biases					
	5.6.1		iveness in learning	207		
	5.6.2		actic learning	209		
	5.6.3		ge subsets vs. grammar subsets	211		
	5.6.4		Constraint Demotion	213		
			RCD and restrictiveness	213		
		5.6.4.2	Estimating the restrictiveness of grammars: the			
			r-measure	215		
		5.6.4.3		216		
	5.6.5		ng restrictiveness in phonotactic learning	220		
			Enforcing restrictiveness with BCD	220		
		5.6.5.2	, , , , , , , , , , , , , , , , , , ,	221		
	5.6.6	-	representation of phonotactic restrictions	222		
5.7		tactic con		224		
	5.7.1		t and the nature of phonotactic learning	224		
. 0	5.7.2		nical form for phonotactic contrast	226		
5.8			rmation underdetermines languages	233		
5.9	The m		, T	236		
5.10	Appen	dix: the S	tress/Length typology	237		
6	Learr	ning with	paradigmatic information	246		
6.1		gmatic inf		247		
6.2	The ex	plosive gr	owth of lexical hypothesis spaces	248		
	6.2.1	Now that	at's big	248		
	622	The bas	ic alternant constraint	248		



xiv	Contents	•	
	6.2.3	Selected prior work	250
	6.2.4	Combinatorics of the Stress/Length linguistic system	252
6.3	An asi	de on methodology	254
6.4	Incons	sistency detection	256
6.5	Setting	g underlying features via inconsistency detection	258
	6.5.1	Feature setting	259
	6.5.2	Setting a single unset feature	260
	6.5.3	Multiple unset features	263
	6.5.4	Multiple words and local lexica	266
6.6	Non-p	honotactic ranking information	269
	6.6.1	Ranking information in local lexica	269
	6.6.2	The join operation	270
	6.6.3	Extracting shared ranking information	272
6.7	The C	ontrast Pair and Ranking (CPR) algorithm	274
6.8	Comp	utational issues for CPR	276
6.9	The m	ар	277
7	Explo	oiting output drivenness in learning	279
7.1	Contra	ast with Richness of the Base	280
	7.1.1	Contrastive for an input	280
	7.1.2	Contrastive for a morpheme	282
	7.1.3	Contrast in output-driven maps	283
7.2	Relativ	ve similarity lattices	284
7.3	Limiti	ng lexical search in output-driven maps	287
7.4	Phono	tactic contrast and underlying feature values	291
7.5	Morph	nemic alternation and non-phonotactic ranking information	294
7.6	Contra	ast pairs	299
	7.6.1	When one word isn't enough	299
	7.6.2	A disjunction of disparities	302
	7.6.3	Restricted rankings create inconsistencies	305
	7.6.4	The roles of alternation and contrast in contrast pairs	308
	7.6.5	Multiple words and relative similarity	310
	7.6.6	Another illustration: setting the stress feature for r1	316
	7.6.7	Setting environment morpheme features	317
7.7	Beyon	d error-driven learning	321
	7.7.1	Uncertainty in the lexicon	323
	7.7.2	Uncertainty about the ranking	328
	7.7.3	Single form learning	332
	7.7.4	Contrast pair learning	334
7.8	The O	utput-Driven Learner (preliminary)	335
7.9	Learni	ng language L20	336
	7.9.1	Phonotactic learning	336
	7.9.2	Initial single form learning	338



				Contents	xv
		7.9.2.1	rlsl		338
		7.9.2.2	r1s4		340
		7.9.2.3	r2s1, r4s1		343
		7.9.2.4	r3s1, r1s3		344
	7.9.3	Contras	t pair learning		345
	7.9.4		single form learning		348
		7.9.4.1	r3s3		348
		7.9.4.2	r4s3, r1s3, r2s3		349
		7.9.4.3	r1s2, r2s4		350
		7.9.4.4	The final learned grammar for L20		351
7.10	The m	ap			352
8	Parad	ligmatic	subsets		353
8.1	The ph	nenomeno	n: paradigmatic subsets		353
	8.1.1		ge L8, the subset language		353
	8.1.2	_	ge L7, the superset language		355
	8.1.3	-	paradigmatic subset of L7		355
8.2	The pr		tempting to learn L8		358
8.3			strictiveness and the lexicon		360
8.4	The so		363		
	8.4.1	The Fev	vest Set Features procedure		363
	8.4.2		nmic details of Fewest Set Features		370
	8.4.3	_	ation to maximum likelihood		372
	8.4.4	Summa	ry: restrictiveness in the lexicon		376
8.5	Evalua		Output-Driven Learner		376
	8.5.1	-			376
	8.5.2	Simulat	ion results		377
		8.5.2.1	No contrast languages		378
		8.5.2.2	Single form learning, no contrast		
			pairs		378
		8.5.2.3	Contrast pairs		379
		8.5.2.4	Fewest Set Features		380
		8.5.2.5	A little perspective		381
	8.5.3	Issues			381
8.6	The m	ap			383
9	Lingu	iistic the	ory and language learnability		385
9.1	_		final lexicon		385
9.2	Forms	of restric	tiveness enforcement		390
9.3	Evalua	ation metr	ics		392
9.4	What is stored by the learner (and why)				394
	9.4.1		g information		394
	9.4.2		information		395



xvi	Contents	
	9.4.3 Structural ambiguity and multiple hypotheses	396
9.5	Beyond output drivenness in learning	398
9.6	What has been accomplished	399
	References	401
	Index	410



Figures

2.1	Relative similarity relation (upward is greater internal	
	similarity).	page 27
2.2	Candidates akx and bmx, and their input-input	
	correspondence.	51
3.1	Candidates akx, bmx, aoy, and bpy.	73
3.2	Relationships among the disparities. Corresponding	
	disparities (same output) are connected with double-sided	
	arrows; analogous disparities (same input) are connected by	
	the square-angled lines.	75
3.3	Candidates akx, bmx, aoy, and bpy.	80
3.4	Relationships among the disparities when $out_y = [tebig]$.	81
7.1	Relative similarity lattice for output [paká:] (higher in the	
	diagram means greater internal similarity).	285
7.2	Relative similarity lattice for output paká: (feature matrix	
	version).	286
7.3	Setting s4 to +long. This is the relative similarity lattice for	
	the output of r1s4, [paká:]. The shaded sublattice contains al	1
	candidates with s4 underlyingly –long.	289
7.4	The relative similarity lattice for r3s4 (nonviable candidates,	,
	with s4 underlyingly -long, are marked with shaded	
	diamonds).	296
7.5	The relative similarity lattice for r1s1. The shaded diamond	
	nodes have r1 underlyingly +long, counter to what has	
	already been set in the lexicon, and so are not viable	
	candidates.	311
7.6	The relative similarity lattice for r1s3. The shaded diamond	
	nodes have r1 underlyingly +long and/or s3 underlyingly	
	+long, counter to what has already been set in the lexicon,	
	and so are not viable candidates.	311
7.7	Relative similarity lattice for r1s1 (viable candidates only).	312
		v v i i



xviii	Figures	
7.8	Relative similarity lattice for r1s3 (viable candidates only).	312
7.9	The joint relative similarity order for the contrast pair r1s1	
	and r1s3. Each node is labeled with underlying forms for r1s1	
	and r1s3, in that order. The left suborder contains all local	
	lexica in which r1 is -stress underlyingly, while the right	
	suborder contains all local lexica in which r1 is +stress	
	underlyingly.	313
7.10	Testing the stress feature for s1. The shaded nodes are the	
	local lexica with +stress assigned to s1 underlyingly.	315
8.1	Relative similarity lattice for r1s1, where s1 has been set to	
	-long.	366
8.2	Viable sublattice for r1s1.	367
8.3	Viable sublattice for r1s1 with inconsistent inputs shaded.	368



Acknowledgments

The work in this book was conducted over a period of several years. During that time, I have benefitted significantly from conversations with a number of people, including Crystal Akers, Eric Baković, Karen Campbell, Paul de Lacy, Jane Grimshaw, Fernando Guzman, Brett Hyde, Gaja Jarosz, John McCarthy, Nazarré Merchant, Alan Prince, Jason Riggle, and Paul Smolensky. I also received useful feedback from several audiences who kindly listened to various incarnations of pieces of this work: the Rutgers Optimality Reading Group (RORG), the Mathematics Association of America Seaway Section and New York Association of Two Year Colleges Fall 2007 Meeting, several meetings of the Northeast Computational Phonology Circle, the Learnability Meets Acquisition Workshop at the 31st Jahrestagung der Deutsche Gesellschaft für Sprachwissenschaft in Osnabrück, NELS39, the Seventh North American Phonology Conference, the Linguistics Department at SUNY Stony Brook, and the Linguistics and Cognitive Science Department at the University of Delaware. Useful comments were also provided by three Cambridge University Press reviewers. Exceptional patience was exhibited by the students of two incarnations of my Seminar on Learnability and Linguistic Theory (Ling670), as well one incarnation of Phonology III (Ling522).

All factual errors and bizarre-sounding conceptions are the sole responsibility of the author.

Special thanks are due to Alan Prince for suggesting the term "output-driven." I wish to thank, for institutional support, the Department of Linguistics and the Rutgers Center for Cognitive Science (RuCCS), at Rutgers, the State University of New Jersey, New Brunswick.

I would like to thank Helen Barton, of Cambridge University Press, for her support of this project and her assistance in getting this work into print.

I wish to express gratitude to my wife, Esther, and my daughters, Heidi and Amanda, for their support and exceptional tolerance of the countless hours I spent in my basement office, working on "the book." Special thanks to Heidi and Amanda for loving me despite the fact that I do not like ketchup.

xix