

**Developmental
Phonological Disorders**
Foundations of Clinical Practice

SECOND EDITION

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Contents

<i>Foreword</i>	<i>xiii</i>
<i>Preface</i>	<i>xv</i>
<i>Acknowledgments</i>	<i>xvii</i>

Part I. Phonology from a Developmental Perspective **I**

Chapter I. Describing Phonological Knowledge at Multiple Levels of Representation	9
1.1 Types of Phonological Knowledge	9
1.2 Describing Articulatory Knowledge	10
1.2.1 International Phonetic Alphabet	10
1.2.2 Visual Analysis of Articulation	13
1.2.3 Kinematic Descriptions of Articulation	14
1.2.4 Motor Equivalence and Articulatory Targets	15
1.2.5 Summary: Articulatory Knowledge	18
1.3 Describing Perceptual Knowledge	18
1.3.1 Distinctive Features and Acoustic Cues	18
1.3.2 Categorical Perception	20
1.3.3 Complexity in Perceptual Encoding	24
1.3.4 Assessment of Perceptual Knowledge	30
1.3.5 Summary: Perceptual Knowledge	33
1.4 Describing Phonological Knowledge	33
1.4.1 Segmental Phonological Knowledge	33
1.4.1.1 <i>The Phoneme and the Phonemic Repertoire</i>	33
1.4.1.2 <i>Allophonic Rules</i>	34
1.4.1.3 <i>Neutralization Rules</i>	35
1.4.1.4 <i>Phonotactic Constraints</i>	37
1.4.1.5 <i>Inventory Constraints</i>	38
1.4.1.6 <i>Independent Versus Relational Descriptions of Segmental Phonological Knowledge</i>	38
1.4.1.7 <i>Covert Contrast</i>	38
1.4.2 Multilinear Phonology	41
1.4.2.1 <i>The Prosodic Hierarchy</i>	41
1.4.2.2 <i>Syllables and Intrasyllabic Units</i>	44
1.4.2.3 <i>Segmental Tiers</i>	46
1.4.2.4 <i>Rules in Multilinear Phonology</i>	50
1.4.3 Phonological Processes	52
1.4.4 Summary: Phonological Knowledge	56
1.5 References	56

Chapter 2. Speech Perception Development	61
2.1 Assessment of Speech Perception Skills in Infancy	61
2.2 Speech Perception Development in Infancy	63
2.2.1 Language-General Phonetic Perception in Early Infancy	63
2.2.2 Environmental Influences on Phonetic Perception in Infancy	67
2.2.3 Perception of Prosodic Units in Infancy	71
2.2.4 Phonemic Perception and Word Learning in Infancy	74
2.3 Speech Perception Development in Childhood	76
2.3.1 Development of Perceptual Representations for Words	76
2.3.2 Development of Segmented Phonological Representations for Words	81
2.4 Mechanisms That Underlie Speech Perception Development	83
2.4.1 Experience Expectancy and Environmental Factors	85
2.4.2 Biological Mechanisms	88
2.4.3 Cognitive Learning Processes	93
2.4.4 Summary	95
2.5 References	96
Chapter 3. Development of Speech Motor Control	103
3.1 Acoustic and Kinematic Studies of Speech Development	103
3.1.1 Syllables and Multisyllabic Utterances	104
3.1.1.1 <i>Infraphonological Description of Infant Speech</i>	104
3.1.1.2 <i>Stages in Infant Speech Development</i>	105
3.1.1.3 <i>Development of Mandibular Control During Babbling</i>	110
3.1.1.4 <i>Organization of Supralaryngeal Articulatory Gestures in Meaningful Speech</i>	112
3.1.1.5 <i>Gestural Goals in Connected Speech</i>	115
3.1.2 Vowels	116
3.1.2.1 <i>Development of the Vowel Space in Infancy</i>	116
3.1.2.2 <i>Vowel Production in Childhood</i>	118
3.1.3 Voice-Onset Time	121
3.1.4 Fundamental Frequency Contours	122
3.1.5 Summary of Studies of Speech Development	124
3.2 Theories of Speech Motor Control	125
3.2.1 Psycholinguistic Models of Speech Production	126
3.2.2 Motor Schema Theory	128
3.2.3 Auditory Feedback Based Models of Speech Motor Control	133
3.2.3.1 <i>DIVA Model</i>	135
3.2.3.2 <i>Experimental Investigations of Feedback and Feed-Forward Mechanisms in Adult Speech</i>	137
3.2.3.3 <i>Development of Internal Models</i>	138
3.3 Factors That Contribute to the Development of Speech Motor Control	139
3.3.1 Maturation of Biomechanical and Neurophysiological Structures	139
3.3.1.1 <i>Maturation of the Vocal Tract</i>	139
3.3.1.2 <i>Maturation of Neurophysiological Structures</i>	141
3.3.2 Access to Sensory Feedback	142
3.3.2.1 <i>Auditory Input</i>	142
3.3.2.2 <i>Somatosensory Feedback</i>	145
3.3.3 Social and Cognitive Influences	145
3.4 References	149

Chapter 4. Phonological Development	157
4.1 Normal Phonological Development	157
4.2 Emerging Phonological Knowledge in Infants and Toddlers	158
4.2.1 Normative Data: Phonetic Repertoires	161
4.2.2 Normative Data: Whole Word Measures	163
4.2.3 Clinical Application of Normative Data with Infants and Toddlers	165
4.3 Normative Data: Preschool and School-Age Children	167
4.3.1 Whole Word Accuracy and Connected Speech Measures	168
4.3.2 Segmental Norms	169
4.3.3 Normative Data for Phonological Processes	179
4.3.4 Acquisition of Prosodic Units	182
4.3.5 Clinical Application of Normative Data with Older Children	191
4.4 Theoretical Issues in Phonological Development	195
4.4.1 Formal Linguistic Theories	196
4.4.2 Cognitive Linguistic Models	199
4.5 Environmental Influences and Physiological Constraints on Phonological Development	202
4.5.1 Cross-Linguistic Studies of Feature Development	203
4.5.2 Speech Perception Skills and Phonological Development	206
4.5.3 Motoric Factors and Phonological Development	208
4.5.4 Lexical Effects on Phonological Development	210
4.5.5 Summary	213
4.6 References	213

Part II. A Holistic Approach to Diagnosis and Treatment Planning	217
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Chapter 5. Assessment of Children with Developmental Phonological Disorders	225
5.1 Planning the Assessment	225
5.1.1 Case History	226
5.2 Obligatory Assessment Tools and Procedures	229
5.2.1 Standardized Single-Word Citation-Form Tests	231
5.2.1.1 <i>Scoring the Articulation Test</i>	233
5.2.2 Stimulability Testing	234
5.2.3 Oral-Motor Screening and Assessment	235
5.2.3.1 <i>Facial Characteristics</i>	237
5.2.3.2 <i>Lips</i>	237
5.2.3.3 <i>Dentition</i>	237
5.2.3.4 <i>The Tongue</i>	239
5.2.3.5 <i>Palatal and Pharyngeal Areas</i>	241
5.2.3.6 <i>Coordinated Nonspeech Movements</i>	242
5.2.3.7 <i>Maximum Performance Tasks</i>	242
5.2.3.8 <i>Standardized Measures of Oral-Motor Function</i>	244
5.2.4 Continuous Speech Sample	247
5.2.4.1 <i>Eliciting the Speech Sample</i>	247
5.2.4.2 <i>Recording the Speech Sample</i>	253
5.2.4.3 <i>Interpreting Speech Sample Performance</i>	254
5.2.5 Hearing Screen	255

5.3	Optional Assessment Tools and Procedures	255
5.3.1	Phonology Skills and Inconsistency Assessment	255
5.3.2	Measures of Intelligibility and Participation Restrictions	258
5.3.3	Language and Cognitive Skills	260
5.3.4	Phonological Processing	261
5.3.4.1	<i>Speech Perception Skills</i>	261
5.3.4.2	<i>Phonological Awareness Skills and Emergent Literacy</i>	264
5.3.4.3	<i>Nonword Repetition</i>	268
5.3.4.4	<i>Auditory Processing</i>	269
5.4	Considerations for Dialect Speakers, Children Speaking English as a Second Language, and Multilingual Children	270
5.4.1	Regional Dialects of American English	270
5.4.2	African American English	272
5.4.3	Children Speaking English as a Second Language, Bilingual and Multilingual Children	274
5.5	Putting It All Together	275
5.6	References	278
Chapter 6. Speech Sample Analysis		285
6.1	Analyses to Select Treatment Goals	285
6.1.1	Phonological Patterns	286
6.1.2	Multilinear Analysis	286
6.1.2.1	<i>Short Tutorial on Multilinear Phonology</i>	289
6.1.2.2	<i>Adequacy of the Speech Sample for a Multilinear Analysis</i>	291
6.1.2.3	<i>Quick Multilinear Phonology Analysis</i>	293
6.1.2.4	<i>Complete Multilinear Phonology Analysis</i>	295
6.1.3	Phonotactic Assessment	310
6.2	Analyses to Track Treatment Progress	312
6.2.1	Syllable Structure Levels	313
6.2.2	Phonological Mean Length of Utterance	314
6.2.3	Weighted Speech Sound Accuracy Measure	317
6.3	Predictive Assessment Procedures	324
6.4	References	327
Chapter 7. Nature of Developmental Phonological Disorders		331
7.1	Classification of Developmental Phonological Disorders	331
7.2	Linguistic Classification Systems	331
7.3	Shriberg's Framework for Research in Speech Sound Disorders	337
7.3.1	Speech Delay—Genetic	341
7.3.2	Speech Delay—Otitis Media with Effusion	342
7.3.3	Speech Delay—Psychosocial Involvement	344
7.3.4	Speech Errors	347
7.3.5	Motor Speech Disorder	348
7.3.6	Clinical Value of the Medical Approach to Classifying Speech Sound Disorders	356
7.4	Psycholinguistic Approach to the Description of DPD	357
7.4.1	Input Processing in Children with DPD	358

7.4.2 Phonological Representations	362
7.4.3 Output Representations	366
7.4.4 Clinical Utility of the Psycholinguistic Approach	373
7.5 Prevalence, Comorbidity, and Long-Term Outcomes	373
7.5.1 Prevalence	374
7.5.2 Comorbidity	375
7.5.2.1 Comorbidity with Specific Language Impairment	375
7.5.2.2 Comorbidity of DPD and Reading Disability	376
7.5.3 Medium and Long-Term Outcomes for Children with DPD	379
7.6 References	381

Chapter 8. Treatment Planning **391**

8.1 Deciding Whether to Provide an Intervention	392
8.1.1 Norm-Referenced Approach	392
8.1.2 Medical Approach	398
8.1.3 ICF Approach	401
8.1.4 Recommended Protocol for Deciding When to Treat	403
8.2 Service Delivery Options	406
8.2.1 How Much Intervention Is Enough?	407
8.2.2 Intensity of the Treatment Schedule	409
8.2.3 Group Therapy	410
8.2.4 Parents as Intervention Agents	410
8.2.5 Summary and Recommendations	414
8.3 Treatment Planning for the Individual Child	415
8.3.1 Goals and Goal Attack Strategies	415
8.3.2 Factors to Consider When Selecting Goals	418
8.3.3 A Randomized Control Trial of Target Selection Strategies	422
8.3.4 Dynamic Systems Perspective on the Selection of Treatment Goals	424
8.3.5 Instructional Objectives	430
8.3.6 Monitoring Treatment Progress	430
8.3.7 Summary	434
8.4 References	434

Part III. Intervention at Multiple Levels of Representation **439**

Chapter 9. Input-Oriented Intervention Procedures **445**

9.1 Focused Stimulation	447
9.1.1 Principles of Focused Stimulation	448
9.1.2 Case Studies of Focused Stimulation to Remediate DPD	452
9.1.3 Empirical Evidence for the Efficacy of Focused Stimulation	454
9.1.4 Summary: Focused Stimulation	457
9.2 Ear Training	458
9.2.1 Case Studies of Computer-Based and Live-Voice Ear Training	460
9.2.2 Empirical Evidence for the Efficacy of Ear Training	462

9.2.2.1	<i>Efficacy of Live-Voice Ear Training Procedures</i>	462
9.2.2.2	<i>SAILS: Computer-Based Speech Perception Training</i>	466
9.2.3	Summary: Ear Training	468
9.3	Dialogic Reading	469
9.3.1	Dialogic Reading Techniques	471
9.3.2	Demonstrations of Dialogic Reading	471
9.3.3	Empirical Evidence for the Efficacy of Dialogic Reading	475
9.3.4	Summary: Dialogic Reading	480
9.4	Conclusions and Recommendations	481
9.5	References	484

Chapter 10. Output-Oriented Intervention Procedures **487**

10.1	Explore Possibilities of the Vocal System	490
10.1.1	Procedures to Encourage Vocal Play	490
10.1.2	Demonstration of Therapy to Encourage Vocal Play	492
10.1.3	Empirical Evidence for the Efficacy of Vocal Play Therapy	494
10.2	Controlled Variability in Babble and Early Words	494
10.2.1	Sensorimotor Procedures to Enhance Dynamic Stability in the Production of Syllable Sequences	495
10.2.2	Demonstrations of Sensorimotor Therapy	501
10.2.3	Empirical Evidence for the Sensorimotor Approach	506
10.3	Intelligible Speech	507
10.3.1	Procedures to Establish Correct Articulation of a New Phoneme	508
10.3.1.1	<i>Demonstrations of Techniques to Establish New Phonemes</i>	515
10.3.2	Stabilization of New Phonemes	518
10.3.2.1	<i>Demonstration of Sound Stabilization Activities</i>	522
10.3.3	Empirical Support for Traditional Procedures	524
10.4	Ongoing Refinements Toward Adultlike Speech	527
10.4.1	Increased Segmental Consistency	527
10.4.2	Increased Motor Stability	530
10.4.2.1	<i>Demonstration of a Therapy Plan for Maintenance</i>	532
10.5	Conclusions and Recommendations	532
10.6	References	535

Chapter 11. Phonological Intervention Procedures **539**

11.1	Word-Based Phonology	540
11.1.1	Core Vocabulary Approach	541
11.1.2	Empirical Basis for Core Vocabulary Approach	545
11.2	Emergence and Reorganization of Phonological Structure	547
11.2.1	Selecting Treatment Goals to Promote Phonological Generalization	547
11.2.1.1	<i>Demonstration of Target Selection to Promote Phonological Reorganization</i>	549
11.2.1.2	<i>Empirical Evidence for Phonological Generalization</i>	552
11.2.2	Promoting Phonological Reorganization	554
11.2.2.1	<i>Demonstration of a Cycles Treatment Session</i>	555
11.2.2.2	<i>Empirical Support for the Cycles Approach</i>	558

11.2.3	Meaningful Minimal Pairs Procedures	558
11.2.3.1	<i>Empirical Support for the Method of Meaningful Minimal Pairs</i>	561
11.3	Explicit Access to Phonological Structure	563
11.3.1	Metaphonological Approaches to Speech Therapy	563
11.3.1.1	<i>Demonstration of Metaphonological Approach</i>	566
11.3.1.2	<i>Empirical Support for the Metaphonological Approach</i>	568
11.3.2	Preventive Emergent Literacy Programs	569
11.3.2.1	<i>Characteristics of Effective Phonological Awareness Interventions</i>	570
11.3.2.2	<i>Evidence-Based Phonological Awareness Interventions</i>	571
11.3.3	Direct Reading and Spelling Interventions	573
11.4	Conclusions and Recommendations	575
11.5	References	576
	<i>List of Illustration Legends, Figures, Tables, Case Studies, and Demonstrations</i>	581
	<i>Index</i>	591

Foreword

Developmental phonological disorders (DPD) are at the center of the profession of speech-language pathology. These disorders have high prevalence in children and frequently accompany other kinds of communicative disorders. A course on DPD is among the first clinical courses in most academic curricula. A sure knowledge of DPD is leverage for understanding other disorders of communication and also for understanding the clinical process itself. The early appearance of the DPD course in a curriculum does not mean it is an easy subject matter. On the contrary, DPD necessarily demands background information from several fields of study, because phonological development, typical or atypical, is a process that draws on a range of knowledge and skills in the developing child. DPD unfolds across several domains of study, including speech perception, speech motor control, phonology and other aspects of linguistics, acoustics, and child development, to name a few. Children are complex, and so is phonological development. The need for cross-disciplinary knowledge is ever-increasing as relevant new information is gathered from fields such as genetics, sociolinguistics, neurolinguistics, and the neurosciences in general. The perspectives in this book are an effective introduction to DPD but also to the larger field of speech-language pathology.

All of the different kinds of knowledge mentioned above are brought to bear on an individual child with a DPD. The way in which the different pieces of knowledge fit together varies from child to child and the enterprising clinician is sensitive to individual differences. Although general patterns can be useful in assessing and treating DPD, ultimately the clinician must recognize the individuality of each child. As the authors note in the introduction to Part I, the development of speech emerges from the interaction of multiple endogenous and exogenous components. To be effective in working with children with DPD, clinicians have to be keen observers, insightful synthesizers, and strategic planners. This sounds like a tall order, and it is. However, Rvachew and Brosseau-Lapr e pave the way to fulfilling that order, beginning with comprehensive and insightful summaries of information from the basic sciences such as speech perception, motor control, and phonological development, and then proceeding to detailed accounts of clinical approaches for assessment and treatment, which are enriched by a large number of demonstrations and case studies that illustrate the blending of art and science in clinical practice.

This book welcomes the reader to participate in a productive learning experience that is systematic and rewarding. The first part of the book arms a reader with extensive background information on phonological representation, speech perception, speech motor control, and normal phonological development. The second part builds on the first by moving into clinical assessment, including general issues in assessment of DPD, speech sample analysis, classification of DPD, and treatment planning. The third part elaborates approaches to intervention, with separate chapters on input-oriented approaches, output-oriented approaches, and phonological approaches. The text is complemented by numerous illustrations, case studies, demonstrations, and tables. Well-defined learning objectives are guideposts to the wealth of knowledge that awaits the reader. The information content of this book is considerable, but the authors have artfully organized the material to take readers through the landscape of DPD. Throughout the book, Rvachew and Brosseau-Lapr e weave scholarship of the highest caliber with practical wisdom gained through clinical experience and clinical teaching. This book is a generous sharing of expertise. Readers of this book

who are new to the profession of speech-language pathology will be well prepared for their first supervised clinical experience in working with a child with DPD. Readers with more experience, even those who have previous coursework in DPD, will find much in this book to warrant close attention and implementation in clinical practice.

Developmental Phonological Disorders: Foundations of Clinical Practice is a book that will have enduring value for individual clinicians and for the profession of speech-language pathology. It is a landmark publication that shows how DPD has matured as a research and clinical specialty. It succeeds in a most difficult undertaking—revealing how complex a subject matter is while showing how that complexity is tractable in the clinic.

—**Raymond D. Kent, PhD**
Professor Emeritus of Communicative Disorders
University of Wisconsin-Madison

Preface

Together we have more than 40 years of experience as speech-language pathologists, mentors, instructors, and researchers in the assessment and treatment of developmental phonological disorders. Children with speech errors or unintelligible speech form the largest part of the speech-language pathology caseload in child-focused settings. It is essential that speech-language pathologists begin their practice with the confidence and competence to assess and treat these children adequately. Many textbooks cover the topic at a superficial level, providing an overview of what is done without explaining *why* or showing *how*. With this book, we aimed to provide the foundations of clinical practice so that even the novice speech-language pathologist can choose assessment and treatment procedures in an evidence-based and child-centered fashion and then implement those procedures correctly and effectively. The first section shows how to describe speech at multiple levels of representation and then describes phonological development from birth through late childhood. The second section shows how to conduct a complete assessment, analyze the child's speech sample to select treatment targets, and interpret assessment data to support the selection of the appropriate treatment approach. The third section describes evidence-based treatment procedures organized according to input-oriented, output-oriented, and phonological approaches. Throughout, clinical practice with a broad range of children is supported, including those with phonological delays, severe phonological disorders, motor speech disorders, and persistent speech errors. The book is targeted at primary developmental phonological disorders, but the general principles of assessment and treatment presented are applicable to children with secondary speech sound disorders. We have in mind four groups of readers, specifically advanced undergraduate or graduate students in speech-language pathology, their instructors, doctoral students, and practicing speech-language pathologists.

Speech-language pathology students will find clear descriptions of assessment and treatment procedures with case studies and demonstrations that illuminate when to use the procedures and how to implement them. Learning objectives at the beginning of each section guide the student through the process of acquiring fundamental conceptual knowledge and learning how to apply that knowledge to clinical practice.

Instructors of courses in phonological development or phonological disorders will find a text grounded in a competency-based approach to teaching. New, updated, and reformatted tables, figures, case studies, and demonstrations support active learning activities in the classroom. For example, activities can be designed by the instructor so that students learn to implement a procedure with a demonstration, practice implementation with a case study, and show their learning with a different case study taken from the book or a local clinic. Instructors can be more confident in the depth of their students' knowledge of important clinical concepts and procedures.

Doctoral students will find the book to be excellent preparation for future roles as instructors and researchers. While clinical students may not need to know all of the detail presented in the first section, instructors must know this detail so that they can answer students' questions when they notice, for example, that different tests yield different conclusions with the same child or that a given treatment procedure does not seem to be effective with all children. Furthermore, the updated research evidence presented indicates where there are gaps in the evidence, providing direction for future research.

Practicing speech-language pathologists will find a leading-edge handbook that details new approaches to speech sample analysis, assessment, and treatment, providing solutions to clinical problems. Whereas many texts focus on prototypical cases, we describe realistic clinical cases—complex children who defy easy diagnosis or cookbook approaches to treatment planning.

It is our hope that this book will raise the standard for instruction in the field of developmental phonological disorders and support competent clinical practice with this population.

Acknowledgments

This book is a collaboration between a teacher and a student, both speech-language pathologists, written with the hope that it will serve other teachers and students, including practicing speech-language pathologists who are working to understand the foundations of our clinical practice and maximize outcomes for the children under their care. We wish to thank those who have taught us—beginning with our most important teachers, the children themselves, many of whom appear in the demonstrations and case studies of this book, thanks to the generosity of their parents, who hope that their child’s speech data will help other children with developmental phonological disorders. We are grateful to many teachers from our past who helped position us to benefit from the large body of published scholarship and create new research that forms the basis for this book. These individuals include Susan’s thesis advisors, Dr. D. G. Jamieson and Dr. E. Slawinski. On a related point we must acknowledge the excellent services offered by the library at McGill University, without which this book could not have been written.

We are indebted to many people who helped us during the writing process by reading and commenting on portions of the book, especially Dr. Ray D. Kent and Dr. Barbara Hodson. Dr. Jon Preston and Dr. Benjamin Munson were also helpful in this regard. We are very happy to share photos and figures provided to us by our very generous colleagues: Dr. Lisa Goffman (Figure 1–5), Dr. Andrea MacLeod (Figure 1–9), Dr. Amy Glaspey (Figure 5–2), Dr. L. D. Shriberg (Figure 7–3), Drs. Edwards, Beckman, Munson, Kurtz, & Windsor (Figure 7–10), and Dr. May (Barbara) Bernhardt (Figure 10–2).

We acknowledge the support of the staff at Plural Publishing throughout the 3-year process with much gratitude. It is with sadness that we note the passing of Dr. Sadanand Singh who, after initiating the project by inviting us to write the book with such enthusiasm and clear vision, was unable to see its completion.

We thank our families whose many sacrifices in support of the writing process are too many to list. Susan expects that Ken and Vivian will stop bringing breakfast in bed upon its publication! Françoise expects Ray, Sophie, and Laura will no longer ask, “Are you done yet?”

Part I

Phonology from a Developmental Perspective

Speech is a quintessential human behavior. The human fetus listens to and learns from speech in the womb and the newborn prefers to listen to the mother's voice above all other auditory inputs. In interaction with their parents, babies engage in heroic efforts to make speechlike sounds, an effort richly rewarded by the emergence of babble by 9 months of age. The use of speech for communication appears shortly thereafter, and by 4 years of age the child is producing meaningful speech in well-formed sentences that are fully intelligible to their communication partners. For some children, the achievement of intelligible speech proves to be an immensely difficult task. The failure to achieve speech that is intelligible enough to serve the social and functional needs of the child in his or her community has immediate and long-term implications that are far from trivial. Learning to help such children is the topic of this book. As with any topic, it cannot be understood fully unless one begins at the beginning. How is it that the typical child learns to produce intelligible speech?

From our perspective, the acquisition of intelligible speech emerges from a perfect marriage of phonetics and phonology. According to old custom, fortuity in marriage requires "something old, something new, something borrowed, and something blue" at the onset. Our approach to the topic has each of these elements. There is certainly no escape from something very old, and that is an ancient debate about the nature of development itself. Throughout the history of human thought, there have been two basic ideas about how developmental change comes about, whether one is talking about concrete structure such

as the embryo or abstract knowledge such as grammatical systems. One view founds development on a process of progressive differentiation whereby all the complex structure that will appear during development is present in some prototypical but undifferentiated form in the initial state; the final predetermined form is actualized through a programmed sequence of divisions into finer levels of structure. This view is described as an "inside out" theory because the primary change agent is situated within the organism. This is the model that underlies Jakobson's (1968) view of phonetic development in which infant babble is seen (wrongly, it turns out) as comprising all of the sounds of the worlds' languages albeit produced in unstructured form. Jakobson also posited that babbling is followed by a relatively silent interval, after which speech development unfolds by an ordered and universal series of splits yielding major sound classes—consonants versus vowels and then nasals versus orals—followed by further divisions within those classes to produce additional oppositions such as those marking place of articulation. An alternative model views development proceeding via an "outside in" process in which external forces act on the initial state to add complexity in successive steps through a series of generative processes.

Babble refers to speechlike syllables produced in a rhythmic fashion by normally developing infants between 7 and 11 months of age.

According to this model of gradual additive complexity, the steps are not built into the original

state and therefore a predetermined outcome is not assumed. Gould (2002) explains that developmental biology tends toward models based on progressive differentiation because of the repeatable and predictable nature of the outcome, whereas evolutionary science relies on the notion of additive complexity as an explanation for outcomes that occur only once as a result of a particular, indeed unrepeatable, trajectory of environmental forces. We strongly recommend Gould's essay that traces the central ideas in these alternative models of development back through the history of science to recurring themes in creation myths. Not only is the essay more entertaining and erudite than anything we can accomplish, it shows clearly that both views are so fundamental and long-standing that one would be foolish to treat either with disrespect or claim that one or the other model is simply wrong. We will, however, go so far as to suggest that the preference for models of progressive differentiation in developmental science is based on an illusion of predetermined outcomes. Our experience as parents and as clinicians in pediatric rehabilitation hospitals provides us with an appreciation for the enormous variability in the developmental trajectories that can occur. The well-known challenge of explaining the coexistence of variability and constancy remains. As with the related "nature-nurture" debate, a new synthesis that dissolves the boundaries between "outside in" and "inside out" processes is required (de Waal, 1999; Spencer et al., 2009).

Esther Thelen (1941–2004), a psychologist well known for her studies of rhythmic movement patterns conducted from a dynamic systems theory perspective, is especially recognized for the *embodiment hypothesis*, the notion that cognition is grounded in our perceptions of and actions on the world throughout the life span.

Thelen and Smith (1994) sought to achieve this synthesis when they presented the dynamic systems approach as "a biologically valid, but nonreductionist, account of the development of behavior" (p. xviii). This perspective provides "something new" to our approach to developmental phonological disorders (DPD) in relation to the dominant approaches of the past four decades. During this time many different theories of phonology have been introduced to speech-language pathologists (SLPs). As outlined

by Ball, Müller, and Rutter (2010), the theories vary greatly in the details of their formal structure and the proposed mechanisms of developmental change. Most theories posit an innately given abstract linguistic structure, providing a distinct preformationist flavor to the underlying "inside out" developmental model. Others draw fairly direct links between speech acquisition and maturation in other domains such as oral-motor and cognitive development, but these alternatives also have difficulty accounting for variable developmental pathways given the linearity of the proposed linkages.

Preformationism is the idea that the form of a living structure preexists its development. Philosophically, this idea is opposed to *epigenesis* and both ideas predate the discovery of the genetic code and the molecular basis of developmental biology.

Recently, dynamic systems theory has been applied to the domain of phonological development (e.g., Bybee, 2001), building on connectionist modeling approaches (Munakata & McClelland, 2003) and earlier constructivist accounts of phonological learning (Ferguson & Farwell, 1975). Within a dynamic system, new behaviors emerge from the interactions among multiple components. Those components that arise endogenously, from the so-called biological aspects of the organism's function, and those that arise exogenously from the physical and social environment have equal importance in the developmental process. The multiple components that contribute to the emergence of a new behavior self-organize to meet the demands of a new task in a specific context. A fundamental characteristic of a dynamic system is nonlinearity—gradual and linear changes at a microscopic scale interact to produce new behaviors that emerge as a macroscopic discontinuity. In this book, speech development is viewed as the emergent product of cross-domain knowledge, environmental inputs, and the social and functional needs of the child. Certain concepts from dynamic systems theory will re-occur throughout, and therefore they are presented in Table I–1 for easy reference. The important concept of multicausality underlies the organization of this text, as is described in more detail in the paragraphs to follow: Part I describes phonological development in multiple phonetic and phonological domains; Part II

Table I-1. Concepts from Dynamic Systems Theory

Multicausality	New behaviors arise from the complex interactions among multiple endogenous and exogenous components that have causal equivalence.
Self-organization	The constraints binding the constituent parts spontaneously break, creating instability, and then the constituents reform into a new, stable configuration.
Phase transition	Nonlinear or discontinuous change in the qualitative behavior of the system at the macroscopic level.
Nonlinearity	Linear change at the microscopic scale drives change at the macroscopic scale; gradual change at the microscopic scale can lead to large discontinuities at the macroscopic scale; even small differences at the beginning state can lead to large differences in the outcome.
Heterochronicity	The constituent components in the system change according to their own separate but interacting timetables.
Control parameter	The last of many necessary components to reach some critical level or to be recruited to the task in a given context before the system moves to a new configuration.
Coordinative structure	A functional grouping of components that provides dynamic stability through synergistic coordination of the components within the system.
Dynamic stability	Occurs when the coordinative structure flexibly self-adjusts to the ongoing demands of the task context.
Representational state	A time-dependent state in which an event in the world is re-presented to the nervous system as a particular pattern of neural activation in the absence of the input that specified the original event.

Source: Definitions are adapted from the following sources: Fogel and Thelen (1987); Smith and Thelen (2003); Spencer and Schoner (2003); Stephen, Dixon, and Isenhower (2009); and Thelen and Smith (1994).

encourages a holistic approach to assessment and diagnosis; and Part III provides explicit instruction in the application of many treatment procedures targeting multiple levels of representation.

Speech development can be seen as emerging from the interaction of multiple endogenous and exogenous components, illustrated in Figure I-1. Throughout development, speech input from the environment is a powerful exogenous component (Figure I-1A). We stress the importance of this variable to the development of speech perception skills, speech motor control, and phonological development in Part I of this book. In Part III, this research on environmental contributions to phonological development is used as a guide to the development and selection of therapeutic approaches to the remediation of DPD. Phonological development is dependent on normal auditory and

perceptual processing of this input (Figure I-1B); we cover the development of speech perception skills in depth in Part I (Chapter 2) and review the literature on the perceptual and phonological processing skills of children with DPD in Part II (Chapter 7), discussing genetic and environmental contributions to deficits in these areas.

Speech perception refers to the construction of a sound-based representation of speech input, enabling many different kinds of operations on that speech input, such as discrimination or identification of sounds and syllables and recognition of spoken words.

The importance of speech practice—ongoing experience with the phonetic substrate of the sound system of the language from the earliest vocalizations in

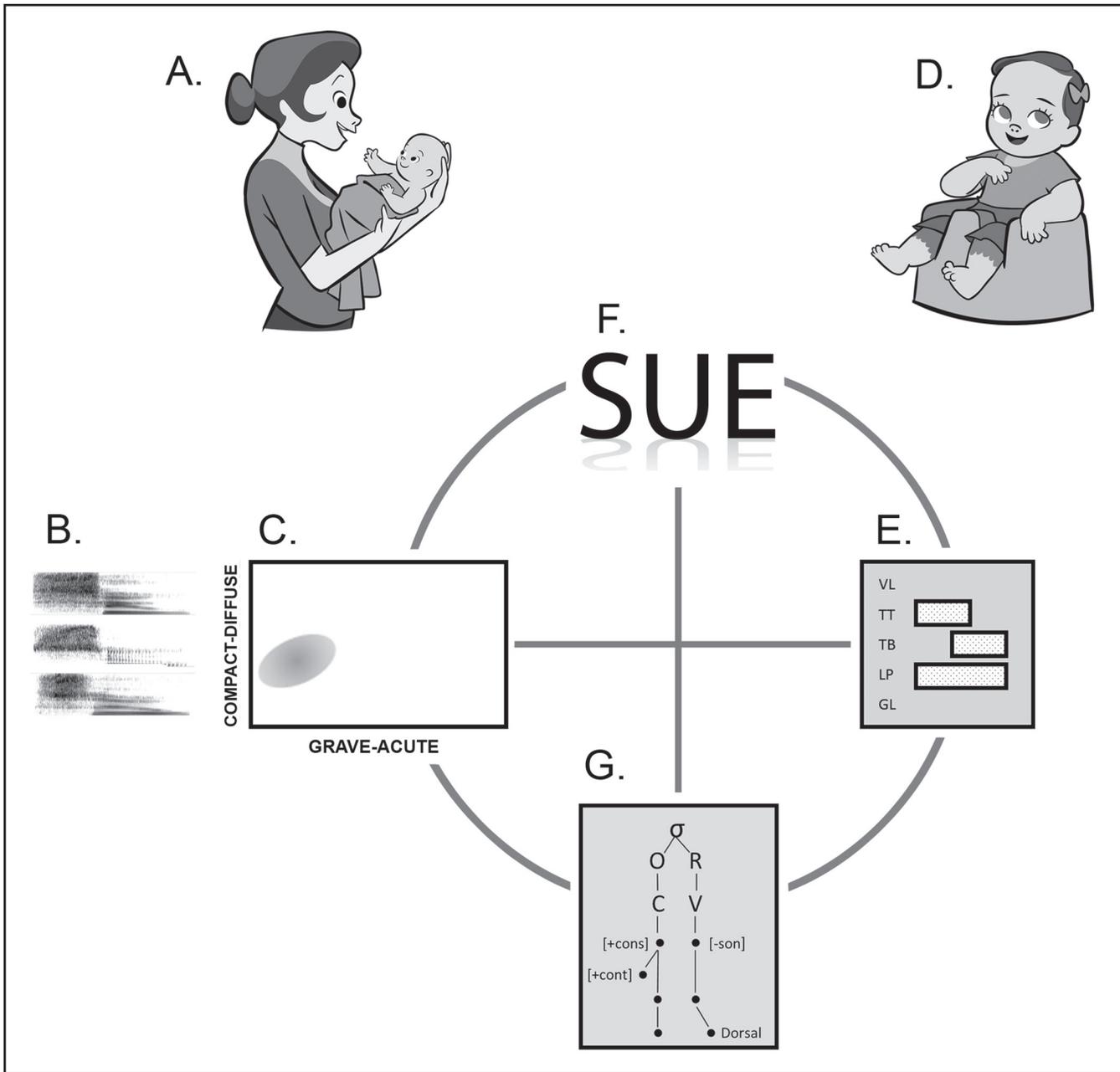


Figure I-1. Schematic of the emergence of phonological representations from the child’s experience with language at multiple levels of representation: (A) language input; (B) stored acoustic exemplars, in this hypothetical example, the child’s name as produced by the mother, the father, and an older sibling; (C) acoustic-phonetic representations of linguistic units, in this example the vowel [u] derived from the distribution of F1-F2 values in the grave corner of the vowel space; (D) the child’s experience with speech in the form of babbled syllables; (E) a gestural score for a CV syllable composed of a coronal sibilant combined with a rounded grave vowel; (F) the semantic representation for “Sue” stored in the lexicon; and (G) an emergent phonological representation for the word that reflects the child’s experience with the phonetic characteristics of the word, the linkages between the representations of the word in multiple domains and the similarities and differences between this word and others in the lexicon at multiple levels of the phonological hierarchy. The concepts and processes will be elaborated throughout the first four chapters of this book in Part I. Original artwork created by Edith Lebel.

infancy—is also stressed as a crucial aspect of phonological development (Figure I–1D). The development of speech motor control from infancy through adolescence is described in Part I (Chapter 3) and interventions to promote speech motor control are covered in Part III (Chapter 10). Lexical development (Figure I–1F) is equally important because, as explained in Chapter 4, phonological knowledge emerges within the lexicon itself; however, lexical development is not covered in detail with the expectation that important aspects of language development that contribute to phonological knowledge will be encountered by the student elsewhere.

The mental **lexicon** organizes information about all the words that a given talker knows, that is, meaning, pronunciation, grammatical inflections, and so forth.

Crucial aspects of social and cognitive development are also raised repeatedly, although individual chapters are not devoted to these important topics. Within a dynamic system it is often difficult to identify the relevant variables, and it is not always obvious which variable is the control parameter that moves the child into a new mode of functioning. For example, the powerful role of shape perception in lexical learning is surprising and therefore not systematically exploited in speech-language interventions (Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). It is hoped that once you are sensitized to the sometimes unexpected nature of these nonlinear relationships, you will be alert to the relevance of learning that will occur outside the context of this text, especially as the future is guaranteed to yield many exciting new discoveries in areas such as neurolinguistics and epigenetics.

Dynamic systems accounts of development have traditionally emphasized sensory-motor processes, “plac[ing] the cause of development in perception-action experience” (Smith, Thelen, Titzer, & McLin, 1999, p. 255). Similarly in language development, phonology emerges from an interweaving of the child’s perceptual and motor experiences during the production of speech. However, representational states play a large role in cognitive and linguistic development (Spencer & Schoner, 2003) and are also crucial during speech development. The conception of linguistic representations adopted in this book is borrowed from proponents of the multiple representations approach

(Beckman & Edwards, 2000; Munson, Edwards, & Beckman, 2005; Pierrehumbert, 2003a, 2003b). Three of several possible levels of representation receive primary emphasis: acoustic-phonetic representations (Figure I–1C) are abstracted from the child’s experience with speech input and help the child recognize speech sounds even when they are produced by many different talkers in varying contexts; articulatory-phonetic representations (Figure I–1E) reflect the child’s knowledge of the articulatory characteristics of sounds and allow planning and production of speech output; and phonological representations (Figure I–1G) reflect knowledge about the sound system that is generalized across the lexicon and linked to perceptual and articulatory knowledge. These three kinds of representations differ from traditional notions of the phone and phoneme in that they are gradient categories rather than discrete units. Furthermore, they are acquired gradually as dynamic and context-specific categories rather than static elements selected from the input in accordance with prespecified options. An organizational scheme for relating linguistic units at the segmental and prosodic levels of the phonological hierarchy has also been borrowed, in this case from Bernhardt and Stemberger (1998).

Gradient categories are frequency distributions of sounds that vary in their acoustic qualities so that they are not all equivalent exemplars of the category; some are better exemplars of the category than the others and listeners are sensitive to fine acoustic details that account for these differences along the gradient in category goodness.

This brings us to the requirement for “something blue,” an element in the wedding ritual that symbolizes fidelity. It has been our goal throughout the writing of this text to remain faithful in every instance to the research evidence. Throughout, we have a particular point of view and have not attempted to present a variety of theoretical perspectives as in a survey text. However, every point made in the text is supported by high quality empirical research. In each chapter, key studies are described in detail and data that may be useful to clinicians and researchers are presented in full. We feel that it is essential for SLPs to understand the research methods that are used to conduct empirical research in phonological development and disorders so that past, current, and future research can be evaluated for its validity and its relevance to clinical practice.

We are using the North American term **speech-language pathologist (SLP)** throughout this book to denote the professional who serves individuals with communication disorders. The designation is meant to be synonymous with equivalent professional titles used on other continents, including *speech therapist* and *speech and language therapist*.

It may seem odd to emphasize the importance of the scientific foundation of the field while invoking a superstition meant to bring luck in a context where there are uncertain outcomes ahead. There is a certain irony but perhaps a hint of felicity too as the model of phonological development that we are supporting here gives an important role to chance as one of many components in a multidetermined system. The child is seen as actively constructing phonological knowledge through his or her own interactions with a complex social and linguistic environment in real time. Certain constraints on what is possible and functional produce an outcome that permits most of us to communicate with each other verbally from an early age. At the same time, chance events account for striking disparities among children in their level of speech and language development that are not usually observed in other developmental domains, even when we restrict our view to those following a normal¹ trajectory. It has been suggested that researchers, looking at variability in phonological development, were “focusing on the wrong properties of linguistic systems” because “the variation that occurs

within a species represents the superficial effects of environmental factors in more accessible structures,” as opposed to the less accessible but invariant and defining structures of the organism (Dinnsen, 1992; p. 192). In contrast, we prefer Blumberg’s (2009) view of archetypal structures when he remarks:

Left to its own devices, nature always takes exception to the rule, undermines the archetype, and reminds us that our ideas about what is natural and what we should do to correct nature’s “imperfections” are as sound as a sandcastle battered by a rising tide. (p. 4)

An **archetype** is the original form of a structure from which all others are copied.

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¹There has been a trend in recent years toward the substitution of the word “typical” for “normal” that has been carried over from casual discourse to scientific writing in a fashion that is imprecise and often inappropriate to the context. The trend appears to date from the appearance of “person-first” style guidelines that promote the use of terms such as “children with language impairment” versus “language-impaired children” to describe research participants. We are in complete agreement with the person-first guidelines and the extension of these guidelines to the description of children in the control groups (American Psychological Association: Public Interest Directorate, 2011). Throughout this book we stress the enormous variability that occurs in developmental trajectories for speech and language development. In fact, we define DPD largely in relation to the distribution of speech accuracy scores within the child population as a whole. We would not describe any particular child as being “normal” or “typical,” thus implying that any one child could exemplify the prototypical standard against which other children can be compared. However, the term “normal” in the scientific sense of a distribution of test scores is essential to the definition of DPD, relating to the “normal curve” and defining a range of test scores that captures the performance levels of the majority of children in the population. We will use the cutoff of one standard deviation below the mean so that children who obtain test scores on measures of articulation and phonology that fall below this cutoff can be identified as falling within the DPD category, as discussed in greater depth in Part II. Notice that in each use of the term “normal” a specific distribution of numbers is the reference and not a whole person or even a population of people. We can expect that every individual will fall at various points along the “normal curve” for different measures of functioning, some of us excelling at language, for example, while failing miserably at swimming and none of us being so bold as to describe ourselves as “typical” exemplars of the human form! We use the term “typical” to describe certain participants of studies where it was the preferred term of the authors of the cited papers. Otherwise, we use the term “normal” to indicate a range of performance levels on a specific measure of developmental functioning for a group of children or to define an individual’s performance on a specific measure relative to the range of scores obtained by a normative group of children. Here again, it is important to remember from your statistics classes that a normative reference is not a group of “normal people” but a distribution of numbers obtained from a defined sample of people, usually but not always constructed to represent the population as a whole. In our view, the term “normal” in its scientific sense describes the observed range of “natural imperfections,” whereas the term “typical” invokes the prescriptive notion of the “archetype” that we are eschewing in this text.

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