Introduction

Bilingual Phonetics and Phonology

An Interdisciplinary Field of Inquiry

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Bilingualism, loosely defined as the ability to use two languages, is in many ways unexceptional and more common than monolingualism in many parts of the world. It has been estimated that probably more than half of the world's population is bilingual (Bialystok, Craik, & Luk, 2012; Grosjean, 2021) and that two-thirds of the children in the world are raised in bilingual environments (Crystal, 1997). Despite this prevalence of bilingualism, the empirical study of monolingual speakers has traditionally outpaced the study of bilinguals because "it is precisely a monolingual perspective which modern linguistic theory takes as its starting point in dealing with basic analytical problems" (Romaine, 1989, p. 1). In spite of this monolingual bias, it is important to note that over the last three decades there has been a monumental growth in interest and research into bilingualism and multilingualism, leading to a better understanding of the linguistic, sociolinguistic, and cognitive aspects of the bilingual individual.

With an ever-increasing presence across multiple disciplines, the field of bilingual phonetics and phonology is also a fast-growing area of inquiry that has been experiencing a rising interest among linguists, researchers, and practitioners. Studies on the phonetics and phonology of bilingualism have examined the speech production, perception, and processing abilities of early and late bilingual individuals, during their infancy, childhood, and as adults, uncovering the linguistic and extralinguistic factors that shape their bilingual phonetic performance. This research has been conducted in speech sciences, with psycholinguistics and sociolinguistics interfacing with studies in second language acquisition (SLA) and second language (L2) pedagogy. In spite of the remarkable development in all of these areas, there is still the absence of a common platform for interdisciplinary discussion on bilingual phonetics and phonology. Our field of study has matured enough to warrant a volume that includes the current and critical accounts of the most important research developments in the field as well as discussions of future directions. For this, I am pleased and proud to present this volume.

The Cambridge Handbook of Bilingual Phonetics and Phonology provides a state-of-the-art survey of and comprehensive guide to research on bilingual phonetics and phonology, striking a balance between depth of coverage in the most widely studied areas and breadth of coverage across sub-areas of the field. The Handbook is aimed at advanced undergraduate students as well as PhD students, but it is also meant to serve as a manual and source book for senior lecturers, professors, and researchers alike. It should be of interest to all linguists, in particular phoneticians, phonologists, as well as psycholinguists, applied linguists, speech pathologists, communication and language acquisition experts, and those interested in cognitive science and language learning. This volume reflects a variety of approaches, theoretical assumptions, and methodological tools that are applied to collect, analyze, and interpret bilingual speech data. The breadth of coverage and the diversity of approaches contained in this volume further ensure that this collection serves readers working on bilingualism, L2 acquisition, laboratory phonology, acoustic phonetics, psycholinguistics, sociophonetics, and language contact. The thirty-five chapters in the Handbook are organized into six sections based on their relationship to one another but also reflecting the diversity of inquiry within those overarching areas. In the remainder of this Introduction, I provide a brief review of the content of each chapter in the form of abstracts, followed by concluding remarks.

Part I: Approaches to Bilingual Phonetics and Phonology

Chapter 1: Generative Approaches to Bilingual Phonetics and Phonology (Broselow)

Generative phonologists share the goal of modeling the internalized grammars that allow members of a linguistic community to produce and understand utterances they have not previously encountered. But while most generativists assume that the internalized grammar maps lexical to surface representations, they may disagree on the nature of that mapping, the makeup of the mental representations of phonological structure, and the role of universal well-formedness constraints in grammar. Broselow's chapter surveys analyses of data from multilinguals, foreign language learners, and loanword adapters within different generative models, exploring both strengths and limitations of competing approaches. In doing so, it explores the strengths and limitations of different models of phonology in accounting for data from bilingual speakers, including the realization of L2 phonemes, allophones, syllables, and suprasegmental structures.

Chapter 2: Usage–Based Approaches to Bilingual Phonetics and Phonology (Brown)

Usage-based approaches maintain that speakers' experiences with language shape how language is stored. Experiences with specific words and word combinations in particular linguistic, discursive, and social

contexts accrue in memory and subsequently contribute to patterns of variability evident in speech productions. In this chapter, Brown introduces chief postulates common to usage-based approaches to language, and then presents an overview of studies exploring the connection between usage patterns and bilingual sound systems as well as studies examining evidence of interlingual influence arising from bilingual lexical storage. The chapter concludes with suggestions for potential avenues for future usage-based research into bilingual phonetics and phonology.

Chapter 3: Sociolinguistic Approaches to Bilingual Phonetics and Phonology (Díaz–Campos, Cole, & Pollock)

Díaz-Campos, Cole, and Pollock account for various contact phenomena in sociolinguistic analysis, and provide context for elaborating on quantitative methodologies in sociophonetic research. Their chapter starts with a background of theoretical concepts that are important for the understanding of sociophonetic contact in the formation of bilingual sound systems. The following sections focus on key social factors that play a major part in sociolinguistic approaches to bilingual phonetics and phonology at the segmental and suprasegmental levels, including language dominance and age of acquisition, as well as topics of language attitudes and perception, and frequently used quantitative methods in sociolinguistics.

Chapter 4: Psycholinguistic Approaches to Bilingual Phonetics and Phonology (Gavino & Goldrick)

Psycholinguistic theories conceptualize the mind as a set of mechanical processes that map between levels of mental representation. Gavino and Goldrick explore how this conceptualization frames psycholinguistic research questions. They first examine how the idea of "mind as computer" leads psycholinguists to examine two broad types of questions. Some studies focus on the structure of mental representations (e.g., Are "similar" speech sounds associated with one vs. two representations across languages?). Others focus on the number and the nature of the processes underlying behavior (e.g., To what extent do speech perception and speech production rely on distinct vs. shared processes?). They then turn to connectionism, a specific computational framework that has dominated psycholinguistic theories of bilingualism. Connectionism's conceptualization of processing as spreading activation has driven studies of representation (e.g., Assuming there are distinct representations in each language, what are the consequences of coactivating the two representations?) and processing (e.g., Assuming there are distinct lexical and phonological processes, what are the consequences of allowing both levels to be simultaneously activated for bilingual processing?). Gavino and Goldrick conclude by considering how psycholinguistic theories can inform as well as be informed by other perspectives.

Chapter 5: Neurolinguistic Approaches to Bilingual Phonetics and Phonology (Llanos & Zinszer)

Llanos and Zinszer provide a cross-sectional overview of current neuro-imaging techniques and signals used to investigate the processing of linguistically relevant speech units in the bilingual brain. These techniques are reviewed in light of important contributions to the understanding of perceptual and production processes in different bilingual populations. The chapter starts with a presentation of several noninvasive technologies that provide unique insights into the study of bilingual phonetics and phonology. This introductory section is followed by a brief review of the key brain regions and pathways that support the perception and production of speech units. Next, they discuss the neuromodulatory effects of different bilingual experiences on these brain regions from shorter to longer neural latencies and timescales. As they show throughout their chapter, bilingualism can significantly alter the time course, strength, and nature of the neural responses to speech, when compared with monolinguals.

Chapter 6: Computational Approaches to Bilingual Phonetics and Phonology (Adriaans)

Computational models allow researchers to formulate explicit theories of early language acquisition, and to test these theories against natural language corpora. While the past two decades have seen great advancements in the modeling of phonetic and phonological acquisition in a monolingual setting, only very few studies have begun to address the modeling of bilingual acquisition. In this chapter, Adriaans puts the problem of bilingual phonetic and phonological acquisition in a computational perspective. He shows how computational modeling can be used to address crucial questions regarding bilingual phonetic and phonological acquisition, which would be difficult to address with other experimental methods. The chapter first provides a general introduction to computational modeling, using a simplified model of phonotactic learning as an example to illustrate the main methodological issues. Adriaans then gives an overview of recent studies that have begun to address the computational modeling of bilingual phonetic and phonological acquisition, focusing on phonetic and phonological cues for bilingual input separation, bilingual phonology in computational models of speech comprehension, and computational models of L2 speech perception. He concludes by discussing several key challenges in the development of computational models of bilingual phonetic and phonological acquisition.

Part II: Theoretical Models of Bilingual Phonetics and Phonology

Chapter 7: The Perceptual Assimilation Model: Early Bilingual Adults and Developmental Foundations (Tyler & Best)

The Perceptual Assimilation Model (PAM) accounts for how native-language (L1) experience shapes speech perception. According to PAM, infants develop phonological categories by attuning to the critical phonetic features that set phonological categories apart (*phonological distinctiveness*) and to the phonetic variability that defines each category (*phonological constancy*). Infants consolidate or improve on their discrimination of L1 contrasts as they attune to the phonological categories, but this is associated with a decline in their discrimination of certain non-native contrasts. The effects of L1 attunement on perception can also be seen in adults. Further, PAM generates predictions about discrimination accuracy for non-native contrasts by comparing how the non-native phones are perceived in terms of L1 phonological categories. The extent to which perception might be altered further by experience with an L2 is outlined by PAM-L2. While PAM has focused on L1 attunement in monolinguals, and PAM-L2 on L2 acquisition in adulthood, their principles also apply to early bilingual language acquisition. In their chapter, Tyler and Best consider the various contexts of acquisition and language use in early bilinguals to sketch out how experience with more than one native language shapes perception and how childhood L2 acquisition might modify the emerging phonological system.

Chapter 8: The Second Language Linguistic Perception Model (Escudero & Yazawa)

Escudero and Yazawa's chapter describes the Second Language Linguistic Perception Model (L2LP), with its five ingredients to explain speech development from first contact with a language or dialect (initial state) to proficiency comparable to a native speaker of the language or dialect (ultimate attainment), and its empirical, computational, and statistical method. They present recent studies comparing different types of bilinguals (simultaneous and sequential) and explaining their differential levels of ultimate attainment in different learning scenarios. Escudero and Yazawa further show that, although the model has the word "perception" in its name, it was designed to also explain phonological development in general, including lexical development, speech production, and orthographic effects. The studies reviewed in the chapter include new methods for examining lexical development and speech production, via implicit word learning and corpus-based analyses, respectively, as well as a novel suprasegmental example of the L2LP Subset problem, which was conceptualized as the reverse of the more common New Scenario, where L2 learners are phased with target contrasts that do not exist in their L1. This chapter also reviews a recent study on the effect of bidialectalism on

L2 acquisition, showing that the L2LP model's explanations apply to speakers not only of multiple languages but also of multiple dialects. Finally, the authors present other topics and future directions, including phonetic training, going beyond segmental phonology, and the formalization of orthographic effects in phonological development. Escudero and Yazawa demonstrate that the L2LP model can be regarded as a comprehensive theoretical, computational, and probabilistic model or framework for explaining how we learn the phonetics and phonology of multiple languages (sequentially or simultaneously) with variable levels of language input throughout the life span.

Chapter 9: The Automatic Selective Perception Model (Shafer)

Perception of L2 speech sounds often is challenging, even for the highly proficient L2 speaker/listener. Speech perception is an active process that requires rapid sampling of the auditory input to recover phonological identity. Even highly proficient L2 listeners can show degraded performance under difficult listening conditions. The Automatic Selective Perception (ASP) model posits that listeners make use of selective perceptual routines (SPRs) that are fast and efficient for recovering lexical meaning. These SPRs serve as filters to accentuate relevant cues and minimize irrelevant information. Years of experience with the L1 lead to fairly automatic L1 SPRs; consequently, few attentional resources are needed in processing L1 speech. In contrast, L2 SPRs are less automatic. Under difficult task or stimulus conditions, listeners fall back on more automatic processes, specifically L1 SPRs. Further, L2 speech perception suffers where there is a mismatch between the L1 and the L2 phonetics because L1 SPRs may not extract the important cues needed for identifying L2 phonemes. After introducing key constructs, factors underlying L2 speech perception, and the ASP model, Shafer presents behavioral and neurophysiological evidence that supports the ASP model, but which also indicates the need for some modification. Finally, Shafer offers suggestions for future directions in extending this model.

Chapter 10: The Ontogeny Phylogeny Model (Major)

Major's chapter discusses the Ontogeny Phylogeny Model (OPM), which focuses on the formation and development of second language phonological systems. It proposes an interrelationship among L2 native-like productions, L1 transfer, and universal factors. The model argues that chronologically, and as style becomes increasingly formal, the L2 native-like processes increase, the L1 transfer processes decrease, and the universal processes increase and then decrease. It further claims that the roles of universals and L1 transfer are mediated by markedness and similarity, both of which slow L2 acquisition. Specifically, in similar phenomena L1 transfer processes persist, while in marked phenomena universal processes persist. The OPM also argues that these same principles obtain for learners acquiring more than one L2,

monolingual and bilingual acquisition, and L1 attrition. In addition to the chronological stages and variation of the individual learner, the model claims that these relationships hold true for language variation and change, including pidgins and creoles.

Chapter 11: Bilingual Speech and Exemplar Theory (Babel, Kamigaki–Baron, & Soo)

A large body of research suggests that users of language have knowledge of both abstracted categories and subphonemic details, providing support for hybrid models of phonetic encoding. Evidence that listeners attend to and track subphonemic phonetic details is indicated by listeners' ability to reliably connect subphonemic variation and, often, socio-indexical associations in ways that align with the patterns realized in production. Bilinguals are presented with the task of not only associating within-language variation (e.g., social group X is connected to a particular range of phonetic realizations within language Y), but also attending to how ethnolects and bilingually accented speech index social categories across languages. Having access to multiple languages also gives bilingual speakers a larger repertoire with which to index language- and community-specific social meaning. In their chapter, Babel, Kamigaki-Baron, and Soo outline the linguistic structures bilinguals may connect across their languages and then present a specific exemplar model, noting the opportunities within the model's structure for bilingual dynamics. The heterogeneity of bilingual individuals and speech communities is also addressed, as this dynamic adds to the complexity and the intrigue of studying bilingual populations.

Part III: The Phonetics and Phonology of the Bilingual Child

Chapter 12: The Speech Perception of Bilingual Infants (Sundara)

Infants hearing more than one language have the complex task not only of detecting patterns of regularity in each of their languages but also of keeping them separate. Sundara's chapter discusses behavioral and neurophysiological findings about how bilinguals perceive spoken language in the first three years of life. This research demonstrates that bilingual and monolingual infants use similar core mechanisms to learn from differing linguistic input. Crucially, comparing their acquisition trajectories allows us to make inferences about the early linguistic representations of bilingual infants. Her chapter begins by presenting key constructs and debates about bilingual language acquisition. She then discusses the representation of suprasegmental properties (lexical stress and tone), word-forms, words, and sound categories. Toward the end, Sundara raises some key considerations on individual differences and processing efficiency for familiar words.

Chapter 13: The Speech Production of Bilingual Children (Kehoe)

Kehoe reviews research on the phonetic and phonological production patterns of children exposed to two or more languages in early childhood (simultaneous bilinguals, consecutive bilinguals, and childhood L2 learners). Much of the research has examined whether bilingual children differ from monolinguals in their production patterns and, when differences have been found, whether such patterns can be explained by language-internal (e.g., the influence of the phonological properties of one language on the other), language-external (e.g., language input or dominance), or other factors (e.g., the developing lexicon). Kehoe considers evidence for monolingual–bilingual differences across an array of phonetic and phonological domains such as voice onset time, rhythm, syllable structure, and segmental acquisition. In particular, she focuses on language-internal influences, also referred to as cross-linguistic interaction, and reviews models that have been used to account for this interaction. Kehoe's review reveals that, while systematic differences between monolingual and bilingual speech exist, the differences are not large and may be explained by multiple factors. The chapter concludes with a discussion of research limitations, which include small participant numbers and a predominance of certain language pairs, factors that have hindered attempts to model cross-linguistic interaction.

Chapter 14: Phonological Disorders in Child Bilingualism (Babatsouli)

This chapter examines phonological disorders in child bilingualism with the goal of informing researchers and speech language pathologists on current definitions, key constructs, tenets, available resources, and challenges in the field, serving to tighten the existing, but overall loose, connection between the study of child bilingual phonological development cross-linguistically and the diagnosis, assessment, and therapy protocols in the context of bilingual children's speech disorders. By drawing on the history of the study of child phonological disorder and summarizing reflections of bilingual acquisition theory within this niche, Babatsouli provides an overarching review of apposite literature to date, discussing the evolution of terms and key issues, and their relevance in bridging the gap between psycholinguistics research, theory, and clinical practice for bilingual children's speech sound disorders. Ultimately, the chapter utilizes existing knowledge to project the canonical perspective that a universal classification of phonological disorder can only be informed by a single mechanism driving its manifestations across children, one that albeit needs to take into consideration every child's spot on the spectrum of disorder, and on the global map of linguistic and cultural diversity.

Chapter 15: Acquisition of Segmental Phonology in Child Bilingualism (Bosch)
Bosch focuses on the acquisition of segmental phonology in simultaneous bilingual children, highlighting the factors that help explain variability in the pathways toward the construction of language-specific phonological systems. She notes that studies so far are still limited and only partial, often restricted to the effects of interaction between specific segments or categories from the two systems to which the bilingual is exposed, and that there is currently no comprehensive theoretical model related to segmental acquisition and the factors that can affect production of language-specific segments in simultaneous bilingualism. Therefore, a broader perspective is suggested in order to better characterize the complex interplay of the elements in this domain. These elements include the properties of the input languages, the young learner's perception–production skills, parallel vocabulary growth, social factors, and language use in bilingual learning contexts. She offers a review of the literature which groups studies by age of participants, a strategy that captures the dynamic nature of the segmental learning processes. It also reveals differences in the methodological approaches for assessing bilingual children's phonological learning, from the production of their first words to more mature levels of phonological knowledge. As a general view, segmental acquisition seems to be characterized by differentiated but interconnected systems, including realignments along this extended developmental process. However, more nuanced approaches are needed, especially related to the perception–production connection and input quality factors, to reach a more comprehensive view of the acquisition of segmental phonology in young simultaneous bilinguals.

Chapter 16: Acquisition of Suprasegmental Phonology in Child Bilingualism (Pronina & Prieto)
Pronina and Prieto's chapter provides the state-of-the-art of the available research on the development of suprasegmental phonology in bilingual children, from infancy through childhood. First, they discuss word-level prosodic phenomena, with a special focus on the bilingual acquisition of word stress and syllable structure, which has been a lively area of research. They also present recent data on the acquisition of tone, which remains a less investigated topic, and consider the acquisition of phrase-level prosody, namely, rhythm and intonation. For each domain of prosodic development, they briefly review monolingual patterns and discuss how learning two (or more) phonological systems can affect developmental trajectories, showing that there can be different cross-linguistic interactions such as transfer, delay, acceleration, or fusion. Pronina and Prieto also consider potential influencing factors that can trigger different tracks in the development of prosody, for example age of onset, amount of exposure, language dominance, and simultaneous or sequential language acquisition. Finally, the chapter concludes with a discussion of avenues for future research.

Part IV: The Phonetics and Phonology of the Bilingual Adult

Chapter 17: The Speech Perception of Bilingual Adults (Antoniou)

Antoniou outlines studies within the domain of speech perception by bilingual adult listeners. The chapter first discuses studies that have examined bilinguals' perception of L1 and/or L2 speech segments, as well as those that have tested perception of unfamiliar, non-native speech segments. In turn, Antoniou examines each of the factors that are known to affect bilinguals' perception of speech, which include age of L2 acquisition, effects of L1:L2 usage as they pertain to language dominance and proficiency, and short-term contextual effects on speech perception. Additionally, he provides an overview of the literature on bilinguals' perception of suprasegmentals. To conclude, Antoniou explores what he considers to be some of the crucial questions facing the field of bilingual speech perception.

Chapter 18: The Speech Production of Bilingual Adults (Casillas)

Adults learning a new language can attest to the difficulty involved in producing the sounds and prosody of the target language. A principal aim of research on adult speech production is to comprehend the mechanisms and processes that differentiate adult bilingual speech development from bilingual speech that develops earlier in life. It is clear that individuals who learn an additional language in adulthood typically encounter some difficulties that early learners do not. In particular, these difficulties arise at the segmental level when acquiring novel sound categories and novel sound contrasts, as well as at the suprasegmental level when learning to produce non-native prosodic structures related to intonation, stress, rhythm, tone, and tempo. In his chapter, Casillas provides a selective overview of the current state-of-the-art in adult bilingual speech production. Furthermore, he considers theoretical and methodological areas for improvement, as well as avenues for future research.

Chapter 19: Phonological Processing and Lexical Encoding in Bilingual Speech (Darcy & Rothgerber)

Bilinguals' recognition of spoken L2 words is characterized by L1 interference in relation to how words are phonologically encoded in the mental lexicon, and how they are activated during comprehension. Darcy and Rothgerber provide an overview of phonological processing during spoken word recognition in bilinguals. Their chapter first describes how phonological knowledge in L1 impacts the processing of native and non-native speech for various phonological dimensions. They then survey major experimental findings in L2 phonological perception and lexical access processes, highlighting the connection between the two, and showing that the phonolexical representations created by L2 learners are L1

influenced. This survey is contextualized by an outline of the various "forces" that further shape processing (e.g., orthography, vocabulary size, or lexical factors). Their chapter closes by outlining how L2 phonological processing develops over time, and how learners succeed at optimizing their processing and creating more target-like phonolexical representations.

Chapter 20: Acquisition of Segmental Phonology in Adult Bilingualism (Steele)

Steele's chapter examines the acquisition of vowels and consonants in perception and production during typical L2 acquisition by sequential, dominant bilinguals. The acoustic and articulatory studies reviewed serve to illustrate general patterns of L2 segmental learning with a focus on four principal themes, each structured around one or two main research questions: (1) cross-linguistic influence (How does a sequential, dominant bilingual's first language shape L2 segmental perception and production?); (2) development (Are there universal patterns to L2 segmental speech development? Are certain vocalic and consonantal phenomena acquired more easily?); (3) inter- and intralearner variability (What are the sources of differences in perception and/or production between learners and for the same learner over time and in different communicative contexts?); and (4) training effects (What are the effects of training on learning? How do variables such as task and stimuli type condition effectiveness?). Steele highlights parallels between the L2 perception and production of vowels and consonants, including the influence of L1 categories and parsing routines; the existence of differences in the relative difficulty of acquisition conditioned by variables such as L1–target language similarity; the effects of lexical (e.g., context, stress, frequency) and learner variables (age of acquisition, length of residence, target language proficiency, memory) on intra- and interlearner variability; and the overwhelmingly positive effects of training on L2 segmental speech learning.

Chapter 21: Acquisition of Suprasegmental Phonology in Adult Bilingualism (Ortega–Llebaria)

Ortega-Llebaria reviews extant L2 prosody research in three sections (word stress, sentence intonation, and rhythm) and presents findings in relation to two underlying themes (form-meaning mapping and additive versus subtractive bilingual contexts). Concerning L2 stress, she first notes that pioneering research framed perception difficulties either as an L1-to-L2 cue-transfer problem or as a processing deficit linked to learners' inability to represent contrastive stress in their lexicons. Additionally, recent research established the extent and the limits of those initial frames. The author then describes that L2 sentence intonation has multiple factors modeling its variation. One of them, social meaning, and in particular accommodation literature, has revealed the effect of affective factors which in multilingual communities become

stronger than linguistic and social factors. As regards L2 rhythm, most research uses duration-based measures. She also mentions that all three topics (stress, sentence intonation, and rhythm) have been studied mostly in contexts of additive bilingualism and in relation to prosodic forms over prosodic meanings, biasing research in L2 prosody. Ending with suggestions for future research that address those biases, Ortega-Llebaria's chapter promotes a more inclusive and comprehensive understanding of L2 prosody.

Part V: The Diversity of Bilingual Speakers

Chapter 22: The Phonetics and Phonology of Early Bilinguals (Mayr, Morris, & Montanari)

Mayr, Morris, and Montanari's chapter provides a thorough, up-to-date review of the literature on the phonetics and phonology of early bilinguals by pulling together studies from a wide range of bilingual settings, including bilingual societies and heritage language contexts. While the chapter mostly reviews evidence from adolescent and adult participants, it also makes reference to the child bilingualism literature, where appropriate. Studies of both speech perception and production are reviewed, and methodological issues are integrated throughout. The chapter first reviews studies on the pronunciation of early versus late bilinguals, followed by a discussion of the various explanatory accounts for the observed differences between these two groups. Subsequently, the critical significance of early linguistic experience on bilingual speech patterns is considered, with particular reference to the evidence from childhood overhearers and international adoptees. The following sections then review studies comparing simultaneous and early sequential bilinguals, and those exploring the role of language dominance, continued use, and the language of the environment in bilinguals' pronunciation patterns. Finally, the chapter looks at the role of sociolinguistic factors in early bilingual speech patterns, and concludes with suggestions for future research.

Chapter 23: The Phonetics and Phonology of Adult L2 Learners in the Classroom (Dmitrieva)

Dmitrieva presents an overview of current and recent research concerning the phonetics and phonology of adult L2 learners in classroom settings, summarizing key findings and suggesting future research directions. In this context, she defines classroom learners as college-aged individuals who are immersed in their L1 and whose L2 learning is limited to the instructional environment of college or university classes. The survey deliberately prioritizes studies that utilize instrumental acoustic analysis or controlled perceptual experiments to assess the phonetic and phonological abilities of L2 learners. Her chapter explores the

following major themes in the surveyed research literature: the role of L2 input quantity and quality, the influence of different phonological targets, the impact of explicit pronunciation instruction and corrective feedback, the extent and implications of individual differences, and the significance of L2 phonetic category formation and L1 restructuring in the classroom-based acquisition of L2 phonetics and phonology.

Chapter 24: The Phonetics and Phonology of Adult L2 Learners After Study Abroad (Nagle & Zárate-Sández)

Study abroad is typically viewed as a catalyst for pronunciation learning because it affords learners both massive amounts of L2 input and abundant opportunities for meaningful L2 use. Yet, even in such an environment, there is substantial variability in learning trajectories and outcomes, which can be traced to varying levels of L2 use, engagement, and other individual differences. The nature of the target structure is also a powerful determinant of learning; some structures seem to develop effortlessly, whereas others do not improve much at all. Additionally, study abroad research brings to light the important issue of speaker identity, as learners often make decisions about how they want to sound and what pronunciation features they will adopt. In their chapter, Nagle and Zárate-Sández examine developmental time frames, trajectories, and turning points in the phonetics and phonology of L2 learners in a study abroad context. They also describe how learners acquire the regional pronunciation variants of their host communities, considering the phonetics of the target feature and learners' attitudes and beliefs. Finally, the authors argue that study abroad should be situated within a dynamic, longitudinal, and context-dependent view of phonetic and phonological learning.

Chapter 25: The Phonetics and Phonology of Heritage Language Speakers (Kim)

Heritage language speakers are early sequential or simultaneous bilinguals whose home language, generally a diasporic or an Indigenous language, differs from the majority language of the society. In this chapter, Kim provides a comprehensive background of heritage speakers and their sound systems. The chapter includes a literature review on the phonetics and phonology across heritage languages, particularly those of children of immigrants, in various majority language contexts. Kim starts the chapter describing heritage speakers and the general characteristics of their language learning experiences and outcomes. She then reviews studies examining heritage speakers' global accent and factors contributing to perceived heritage accent. The chapter continues by presenting areas of divergence that have been found in the production and perception of heritage language segments and prosody. As a conclusion, Kim synthesizes the findings, discussing common patterns observed in

heritage language phonetics and phonology, and suggesting areas for future research.

Chapter 26: The Phonetics and Phonology of Indigenous Language Bilinguals (Baird & Mulík)

Baird and Mulík describe Indigenous languages as predominantly minority languages spoken by linguistically distinct and often socially and scientifically marginalized and vulnerable ethnic groups, autochthonous to a specific region of the world, and found in diglossic contexts with majority international languages resulting from colonization. These can range from relatively well-known Indigenous languages, such as Quechua, Basque, or Hawaiian, to lesser-known languages that might be severely endangered and exclusively oral. The dynamic and asymmetrical character of Indigenous bilingualism, along with the vast number of language combinations and the speaker community size differences between the members of these language pairs, sets it apart from other types of bilingualism with coverage in this Handbook. The chapter reviews available literature on the phonetics and phonology of Indigenous language bilinguals published in the last few decades, focusing on both of the bilinguals' languages, the interaction between their phonological systems, and the phonetic realizations of the sounds present in their languages.

Chapter 27: The Phonology of Bimodal Bilinguals (Lillo–Martin, Gu, Kozak, & Chen Pichler)

Lillo-Martin, Gu, Kozak, and Chen Pichler consider aspects of phonology for bimodal bilinguals, whose languages span distinct modalities (spoken/signed/written). As for other bilinguals, the primary issues concern the representation of the phonology for each language individually, the ways that the phonological representations interact with each other (in grammar and in processing), and the development of the two phonologies, for children developing as simultaneous bilinguals or for learners of an L2 in a second modality. The authors note that research on these topics has been sparse, and some aspects have hardly been explored at all. The findings presented in this chapter indicate that, despite the modality difference between their two languages, phonological interactions still occur for bimodal bilinguals, providing crucial data for linguistic theories about the locus and mechanisms for such interactions, and important practical implications for language learners.

Chapter 28: Comparing Bilingual and Trilingual Phonetics and Phonology (Gut & Wrembel)

There has been a notable increase in research on the acquisition process in a multilingual context, which has become recognized as an independent field, quantitatively and qualitatively different from SLA. A growing body of studies into the acquisition of third language (L3) phonology demonstrates an

inherent complexity of the field reflected, among others, in multidirectional dynamic cross-linguistic influence. As shown, multilingual learners have at their disposal a broadened phonetic and phonological repertoire, a raised level of metalinguistic awareness, and enhanced perceptual sensitivity, which may facilitate the learning of subsequent phonological systems. In their chapter, Gut and Wrembel compare bilingual and trilingual phonetics and phonology by providing an overview of recent research into both subdomains, identifying their common features and, importantly, their points of departure for L3 phonology, with a view to providing new insights into the acquisition of speech.

Part VI: Variables and Outcomes of Bilingual Speech

Chapter 29: Language Dominance Effects in the Phonetics and Phonology of Bilinguals (Birdsong & Amengual)

Researchers in bilingualism seek to identify factors that are associated with specific features of bilingual speech. One such predictive factor is language dominance, typically understood as the degree to which one of the languages of a bilingual is more often and more proficiently used. In their chapter, Birdsong and Amengual review landmark studies that demonstrate the power of language dominance in predicting fine-grained phonetic and phonological characteristics of speech production and on the perceptual and processing abilities in one or both languages of bilinguals. They then critically examine the construct of dominance and identify ways in which dominance can be and has been measured, as well as challenges inherent in the measurement of dominance. After demonstrating the dynamic character of dominance, they review research on dominance switches and shifts, which is followed by a review of extant studies on language dominance in bilingual speech production, perception, and processing in both languages. They conclude with four areas where research can be fruitfully directed.

Chapter 30: Code–Switching and Language Mode Effects in the Phonetics and Phonology of Bilinguals (Olson)

The interaction between bilingual phonetic systems is dynamic, shaped by both long-term (e.g., immersion, acquisition) and short-term factors (e.g., language mode, code-switching). Short-term factors, the focus of Olson's chapter, refer to immediate changes in the linguistic situation. Olson discusses two short-term sources of potential phonetic interference: code-switching and bilingual language mode. Code-switching, defined as the alternation between two languages in a single conversation, represents a situation in which both of a bilingual's languages are activated. A growing body of research on the phonetics of code-switching has shown that code-switching may result in phonetic interference between

the L1 and the L2, although outcomes may vary across speakers and features. Language mode describes a bilingual's position along a continuum, from operation in a monolingual mode, in which only one language is active, to bilingual mode with equal activation of both languages. Shifts in language mode can be driven by linguistic forms, interactional situations, and interlocutor characteristics. Recent work has demonstrated that language mode may modulate cross-linguistic phonetic interference, with greater interference found during bilingual mode. In his chapter, Olson provides an overview of studies on code-switching and language mode and examines two variables responsible for modulating and constraining phonetic interference in cases of dual language activation that have emerged in the literature – the nature of the phonetic feature and bilingual language dominance.

Chapter 31: Orthographic Effects in the Phonetics and Phonology of Second Language Learners and Users (Bassetti)

Bassetti's chapter reviews evidence that the orthographic forms (spellings) of L2 sounds and words affect L2 phonological representation and processing. More specifically, she shows that orthographic effects are found in speech perception, speech production, phonological awareness, and the learning of words and sounds. Previous research has shown that orthographic forms facilitate L2 speaker/listeners – for instance in lexical learning – but also have negative effects, resulting in sound additions, deletions, and substitutions. This happens because L2 speakers' L2 orthographic knowledge differs from the actual working of the L2 writing system. Orthographic effects are established after little exposure to orthographic forms; are persistent; can be reinforced by factors other than orthography, including spoken input; and are modulated by individual-level and sound/word-level variables. To conclude, Bassetti invites future research that addresses gaps in current knowledge, for instance investigating the effects of teaching interventions, in order to aim at producing a coherent framework.

Chapter 32: Phonetic and Phonological L1 Attrition and Drift in Bilingual Speech (de Leeuw & Chang)

In their chapter, de Leeuw and Chang present an overview of what is currently known about phonetic and phonological L1 attrition and drift in bilingual speech and introduce a new theory of bilingual speech, named Attrition & Drift in Access, Production, and Perception Theory (ADAPPT), which devotes special attention to L1 change. Attrition and drift are defined and differentiated along several dimensions, including duration of change, source in L2 experience, consciousness, agency, and scope. The chapter addresses why findings of attrition and drift are important for our overall understanding of bilingual speech and draws links between ADAPPT and well-known theories of L2 speech, such as

the revised Speech Learning Model (SLM-r), the PAM-L2, and the L2LP model. More generally, the significance of findings revealing attrition and drift is discussed in relation to different linguistic subfields, such as sociolinguistics, usage-based theory, and generative linguistics. The chapter raises the question of how attrition and drift potentially interact to influence speech production and perception in the bilingual's L1 over the life span and concludes by pointing to additional directions for future research.

Chapter 33: Bilingual Speech Intelligibility (Bradlow)

Bradlow's chapter presents the Talker-Listener-Language, or TL2, framework for analyzing variation in speech intelligibility in conversational interactions between interlocutors from different language backgrounds. The TL2 framework is based on three fundamental relations: (a) the relation between the talker and the language being spoken (Talker-LBS), which can vary from low proficiency L2 to L1; (b) the relation between the listener and the language being spoken (Listener-LBS), which also varies from low proficiency L2 to L1; and (c) the relation between the language repertoires of the interlocutors (Talker-Listener), which can either match or mismatch. These foundational relations provide a scaffold for classifying conversational interactions based on the overall language profile of the interaction. The central claim of the TL2 framework is that each of the three language relations influences speech intelligibility both independently and through modulation of the others. In this chapter, Bradlow provides evidence from various independent strands of research on speech intelligibility for L1 and L2 talkers and listeners to support this claim. The TL2 framework is thus presented as both a coherent perspective on prior research on bilingual speech intelligibility and a map for future research.

Chapter 34: Using a Characteristic Speech Production (CSP) Procedure to Elicit Monolingual and Bilingual Speech (Flege)

Many have expressed concerns regarding the replicability of scientific research. However, little of this ongoing discussion has focused on research examining the production of vowels and consonants or the many choices that researchers must make in pre-analysis phases of speech production research. In his review of the literature, Flege shows that not all speech production studies have been replicated, and that how speech is elicited may affect the results that are obtained. He also notes that many different elicitation techniques are in current use, but none represents a gold standard. He then introduces the Characteristic Speech Production (CSP) technique, which aims to augment replicability by obviating the need for participants to accommodate their speech to that of others or adopt a particular speaking style as they give meaningful answers to meaningful questions. Flege's chapter provides a protocol that is designed to test its efficacy. If the CSP technique

can be shown to yield speech samples that are more representative of individuals' speech than a standard list-reading technique, a change in how speech is elicited for production research will be warranted.

Chapter 35: Bridging the Gap between Bilingual Phonetic Research and Pronunciation Teaching (Levis & Nagle)

Pronunciation teaching is often based on assumptions that language learners are monolingual speakers, with the sound system of their native language determining the segmental and suprasegmental difficulties that mark learners' foreign accents. However, many, if not a majority of speakers of other languages come to pronunciation with more than one language under their command. These bilingual/multilingual speakers are the norm in a globalized world, but how we teach pronunciation rarely accounts for the knowledge and skills these speakers bring to the learning of pronunciation. Levis and Nagle describe how the characteristics of bilingual speakers suggest how pronunciation teaching can be reimagined to take into account the range and flexibility of bilingual speakers in using multiple languages. Specifically, they argue that taking a nativeness viewpoint is inconsistent with taking a bilingual viewpoint, and call for pedagogical techniques that build on the kinds of needs that bilingual speakers have in pronouncing additional languages.

Concluding Remarks

Bilinguals differ greatly from one another in terms of their linguistic experience and (socio)linguistic profiles. They include individuals who acquired both of their languages during childhood in societal bilingual settings, adults learning their second language in a classroom setting or in an immersion context, speakers of Indigenous languages that have been in contact with other majority (colonial) languages, heritage speakers of diasporic languages spoken by children or grandchildren of immigrants, and those who use two languages in different modalities. As diverse as the individuals that we investigate, the researchers on bilingual phonetics and phonology have espoused interdisciplinarity in their approaches and viewpoints, employing novel data collection techniques and sophisticated experimental designs, and obtaining empirical data from an increasing number of language pairs.

These are exciting times to be conducting research on bilingual phonetics and phonology. The depth of inquiry in our field is clear evidence that researchers on the sound structure of bilingual speakers/hearers are active and significantly moving the field forward. Each chapter included in this Handbook, written by world-leading experts, contributes to this diversity of approaches, to theory-building, and to the collaborative and interdisciplinary connections that are enhancing and enriching our field, while also providing a roadmap for the future of scholarship in bilingual phonetics and phonology.

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