Part I

Introduction

1

Bilingual processing

A dynamic and rapidly changing field

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1.1   Introduction

How does a bilingual acquire, comprehend, produce, and control multiple languages in one mind? What are some of the cognitive and neurocognitive consequences of being a bilingual? These are just a few of the intriguing theoretical questions at the core of studying bilingualism from psycholinguistic and neurocognitive perspectives. For decades, researchers have been fascinated by how the human mind processes multiple languages. With intensified research efforts have come insightful inquiries, pioneering theories, and implications for future research. Perhaps an example of one of the earliest and most studied questions related to psycholinguistic perspectives of bilingualism is: whether humans have a separate or shared (whether fully or partially shared) system for the representation and cognitive processing of multiple languages (Kolers, 1963; McCormack, 1977; Weinreich, 1954). Although much progress has been made, this question will continue to be one of many topics of interest in this handbook.

It is clear that we can now argue that Bilingual Processing is an entire field of study on its own, yet there continue to be many unanswered questions and gaps that merit fine-tuning and special attention as in any growing research field. Indeed, there are several up-and-coming and innovative themes currently being debated in the field of Bilingual Processing, many of which will be discussed in this handbook. These issues have appeared and developed at rapid speeds in just the last couple of decades and new venues have been dedicated to them such as in handbooks and course books (de Groot, 2011; Grosjean & Li, 2013; Kroll, 1997; Kroll & de Groot, 2005), journals such as *Bilingualism: Language and Cognition* co-founded by editors Grosjean, Kroll, Meisel, and Muysken (1998), and a new book series Bilingual Processing and Acquisition founded by editor Schwieter (2014).

As the well-known fact that the majority of the world knows more than one language becomes stronger and more evident than ever and studies in Bilingual Processing continue to gain momentum, it is essential to capture the current state of a blossoming research field. *The Cambridge Handbook of Bilingual Processing* seeks to provide a unified home, unlike any other which showcases not only traditional and contemporary thematic areas within Bilingual Processing, but also topics that are reshaping what we know about the bilingual mind and are now considered prominent research areas. For instance, with the increase of research looking at language control processes in the last few decades, a section specifically dedicated to language control is featured in this handbook. While prior titles have explored language control within other thematic areas, it has become apparent that control is a vibrant area of investigation that cuts across multiple areas of bilingual processing (acquisition, comprehension, production, domain general control, etc.) and merits a complete section of its own. In all, this handbook offers a comprehensive overview of the key areas of study related to Bilingual Processing as identified and elaborated on by some of the leading scholarly authorities from around the world in the form of thematic chapters which together have been critiqued by over seventy international peer reviewers.

The Cambridge Handbook of Bilingual Processing is a comprehensive title which will take readers on a journey that begins with the origins of the field approximately sixty years ago and then explores current research trends and ends with thought-provoking implications and ideas for future research directions. During this exploration, the reader will be led through six parts that investigate areas including: theories and methodologies; acquisition and development; comprehension and representation; production; control; and the cognitive and neurocognitive consequences of bilingualism. The part on theories and methodologies introduces the reader to the history and development of the field of bilingual processing (Chapter 2) and also explores topics such as conceptual and methodological perspectives using computational models (Chapter 3), along with dialogues on the methods of studying Bilingual Processing among both adult (Chapter 4) and infant bilinguals (Chapter 5). The part on acquisition and development presents topics such as: whether there are different learning pathways in acquiring two languages from infancy (Chapter 6); phonology and morphology in lexical processing (Chapter 7); processing perspectives of second language (L2) instruction (Chapter 8); laboratory-based studies of L2 vocabulary learning (Chapter 9); transfer and usage-based theories of L2 acquisition (Chapter 10); and learner and language developmental variation from a dynamic approach (Chapter 11).

The part on comprehension explores topics such as language specificity, transfer, and conceptual change (Chapter 12); processing of emotion words (Chapter 13); processing implications of orthographic similarities between languages (Chapter 14); lexical access in sentence comprehension

(Chapter 15); and the role of the first language (L1) in the syntactic processing of the L2 and vice versa (Chapter 16). The part on production presents a dialogue on the individual characteristics that may cause variation in language production processes (Chapter 17); interpretations of parallel language activation and word production using computer simulations (Chapter 18); implications of naturally occurring code-switching on bilingual production models (Chapter 19); and cognitive and neurocognitive perspectives on intra-sentential code-switching (Chapter 20). The part on control is dedicated to a rather new area of inquiry in Bilingual Processing. In this part, the reader will find a set of chapters exploiting issues related to the cognitive control of two languages, including: language selection, activation, and control (Chapter 21); the mechanisms and scope of language control (Chapter 22); behavioral measures and other methodological issues in language control (Chapter 23); and neural perspectives of language control (Chapter 24).

The part on the consequences of bilingualism explores in depth the notion that bilingualism may incur cognitive benefits. In this handbook, we will refer to this as the bilingual advantage debate and the first three chapters of this part discuss topics such as cognitive reserve and executive control (Chapter 25); the potential explanatory power from bilingual social psychology perspectives (Chapter 26); and neural perspectives of brain plasticity (Chapter 27). The subsequent chapters review the effects of bilingualism on the mental lexicon (Chapter 28); factors influencing native language attrition (Chapter 29); and the effects of knowing more than two languages on language processing and learning (Chapter 30).

We have organized the sections below according to the six parts of the handbook to introduce the chapters and to highlight their importance along with their fit in the field at large.

1.2 Theories and methodologies

The section on theories and methodologies begins with a review of the research on bilingual language representation and processing in adults by Jiang that also includes a review of the relevant models that have been proposed over the decades. This review is then expanded upon in a chapter on the use of computational models to study bilingual processing and learning by Li and Zhao. Spivey and Cardon then shift the discussion to theories and methods of research on adult bilingualism, including some of the key issues studied in this area. Byers-Heinlein then does so in the context of infant bilingualism. Taken together, the chapters presented in this section describe the major methods and theories in bilingual processing from infants to adults, and emphasize the need for converging approaches to successfully answer questions about bilingual language learning and processing.

1.2.1   The development of bilingual representation and processing

In Chapter 2, Jiang reviews the research in the area of bilingual language representation and processing that has taken place during the past six decades, beginning with the 1950s. He reviews the early work on classifying types of bilingualism and assessing the degree of bilingualism. There is a discussion on issues of bilingual lexical organization and processing, including the key questions of whether bilingual language activation is fundamentally selective or non-selective. There is also a review of research on how bilinguals control access to the two languages. Throughout this chapter, Jiang provides an overview of the variety of methods that have been used to examine the relevant issues.

The chapter also includes an overview of the relevant models that have been proposed to explain the way that words are represented in the two languages, and how these representations are interconnected. The chapter concludes with a useful timeline demonstrating when the various models were introduced, providing the reader with a visual representation of the changes in the field.

1.2.2   Conceptual and methodological perspectives using computational models

Li and Zhao present in Chapter 3 an overview of computational models of bilingual language learning and processing. They emphasize the importance of modeling for advancing the field, and note that models force researchers to be explicit about the assumptions they are making. They further propose that computational models in particular may be especially helpful in dealing with complex interactions between multiple factors, which are common in bilingual processing and learning. Their review focuses on models from the connectionist (i.e., Parallel Distributed Processing) tradition, which emphasizes emergentism and dynamism as key features of the language system.

Li and Zhao describe some of the major distinctions between the various types of connectionist models, specifically whether the models use localist or distributed representations (e.g., as derived from co-occurrence metrics), and whether the learning mechanism employed is supervised or unsupervised. They review several specific models, including models informed by the interactive activation model of McClelland and Rumelhart (1981) including the Bilingual Interactive Activation (BIA) and BIA+ models, the Bilingual Single Network Model, and the Bilingual Simple Recurrent Network Model. Li and Zhao also include a useful overview of self-organizing maps models, which are a type of unsupervised model that uses topographic maps to organize input representations. This up-to-date review provides some recent models that make important and

unique contributions to the literature, such as a model of recovery from bilingual aphasia (Kiranet et al., 2013) and a model that tests entrenchment as an alternative to the critical period hypothesis (Monner et al., 2013). The chapter concludes with a suggestion (see also Addyman and French, 2012) that user-friendly interfaces be offered to non-modelers to further advance the field.

1.2.3   Methodological considerations for adult bilinguals

Chapter 4 by Spivey and Cardon presents an overview of methods for the study of adult bilinguals. They emphasize the importance of generalizability to naturalistic contexts, ease of use in the field, and sampling richness. They describe a variety of methods in detail. In particular, they begin with methods that measure the end product of processing (e.g., an offline grammaticality judgment task), followed by methods that involve reaction time measurements (e.g., semantic priming). They also review the use of neuroimaging methods such as ERP and fMRI and discuss some of the advantages and pitfalls of using these methods. They conclude with a discussion of methods that involve many repeated measurements (e.g., eye tracking).

Spivey and Cardon emphasize the usefulness of these dense-sampling methods, noting that they allow for the examination of processing as it unfolds over a larger timescale than the single-trial time frame that is typically studied. As an example, they describe the use of time-series analysis for an unscripted conversation between individuals. Other similar methods use mouse tracking and eye tracking to gain insight into these processes. Spivey and Cardon advocate for the use of converging methods to provide a better-informed view of bilingual language processing and discuss the bilingual advantage as a particular area that has benefited from research from converging methodologies.

1.2.4   Methodological approaches for infant bilinguals

Chapter 5 by Byers-Heinlein presents an overview of the issues involved in the study of bilingual infant processing. The discussion includes a variety of factors involved in the definition of an infant as "bilingual," the role of length, timing, constancy, and context of exposure to two languages, and issues involved in stimulus selection for studies with bilingual infants. Furthermore, Byers-Heinlein presents an overview of the key methods used to study bilingual infants, including high-amplitude sucking, visual habituation, and preference paradigms. Several preference paradigms are described, including the anticipatory eye movement procedure, the switch procedure, and the intermodal preferential looking procedure.

This chapter also includes a review of the two brain-based methods that are used to study bilingual infants: ERPs and functional near infra-

red spectroscopy. These methods are noted to be useful in the study of bilingual infants because they do not necessarily require a response from the infant and can demonstrate whether bilingual and monolingual infants process information using similar brain structures and on a similar timescale. The chapter concludes with suggestions regarding the selection of stimuli for studies with infant bilinguals.

1.3 Acquisition and development

Part III on acquisition and development begins with a discussion on the learning pathways taken by bilingual and monolingual children by Sebastián-Gallés (Chapter 6). She emphasizes the need for bilingual children to separate their multiple language systems, and the possible cognitive benefits this may confer. Gor continues in this vein in Chapter 7 and discusses the interaction between the various levels of the language system and how phonological and lexical processing interact. This emphasis on the various levels of language is continued by VanPatten (Chapter 8) who argues that it is critical for pedagogical interventions to focus on processing so that the creation of form-meaning mappings through successful comprehension is achieved. Tokowicz and Degani (Chapter 9) proceed with a discussion of interventions, but focus instead on laboratory studies of adult second language vocabulary learning. They discuss the benefits of studying naïve learners in a controlled lab setting in addition to studying ongoing learning in more naturalistic contexts. Ellis, Römer, and O'Donnell (Chapter 10) use converging methodologies to examine learning of constructions in the L2 and demonstrate that the use of verb–argument constructions (VACs) is influenced not only by the usage of words in language but also by transfer from the learner's L1. Lowie and de Bot (Chapter 11) conclude Part III by discussing a newer framework for understanding the development of an L2, Dynamic System Theory (DST), drawing connections to emergentist views of language. This approach emphasizes the interactions of various dynamic subsystems rather than the fixed representations in other contemporary theories.

1.3.1 Learning pathways

In Chapter 6, Sebastián-Gallés reviews research on whether bilingual and monolingual infants and children follow similar or different learning pathways. The available evidence suggests that, by and large, there are not qualitative differences in pathways taken by bilingual and monolingual children. Instead, although bilingual and monolingual children share basic mechanisms, bilingual children must learn two repertoires of sounds and two language systems, which requires additional computation

on their part. This additional computation allows them to separate these multiple systems and avoid interference between them, which bilingual children are able to accomplish without delays or confusion.

Sebastián-Gallés then links this idea to the research on bilingual advantages, and notes that the additional computation required by bilingual children may confer an advantage on them relative to monolingual children in terms of memory and/or inhibitory ability. These advantages may temper the purported disadvantage in terms of vocabulary size that may be due to the way that the number of words known is counted across languages, exposure differences between bilinguals and monolinguals, and socioeconomic differences between groups in previous studies. The chapter ends with a discussion of the importance of the under-studied topic of cross-language similarity because similarity at a variety of levels of language is likely to influence the learning trajectory.

1.3.2 Phonology and morphology in lexical processing

Gor begins Chapter 7 with an overview of phonology and morphology in lexical processing. There is a focus on words processed in isolation, asking how phonological learning and vocabulary learning interact. The chapter reviews four important models of native and non-native phonetic perception. In particular, two contrasting theoretical views of how auditory input is converted into lexical representations are presented: the episodic and abstractionist views. Ultimately, Gor argues for a hybrid abstractionist–episodic model that includes abstract representations that are attuned phonetically and remain flexible. She then presents evidence from a training study consistent with this view.

This follows with a review of the varying views on whether phonetic categorization precedes lexical representation or vice versa (the categories first and lexicon first positions) and argues that acquisition of phonemes and words proceeds in parallel and these processes bootstrap each other, leading to data that support both positions depending on a variety of factors. The chapter reviews evidence that orthography helps in the consolidation of phonological representations and in the role of allophonic variation in processing of phonetic contrasts in the L2. Gor concludes with evidence that bilinguals are able to process L2 morphology decompositionally but that the likelihood that this process will succeed depends on several factors including L2 proficiency and the frequency of the L2 word form.

1.3.3 Instruction based on processing perspectives

VanPatten in Chapter 8 articulates an argument for pedagogical interventions that take a processing perspective. In particular, he lays out a view of the nature of language as involving aspects of language that are innate and cannot be learned, aspects that are derived, and aspects that must be

learned. What follows from this is that the problem for learners is to be able to process linguistic input, which is defined as successfully making form-meaning mappings in real time (i.e., correct sentence comprehension). Such processing instruction involves providing the learner with structured input, which is contrasted with noticing, which is said to affect attention to the input, rather than helping to foster form-meaning mappings per se.

The chapter includes a specific example of a processing-oriented peda-gogical intervention called processing instruction. This example demon-strates the important features of this type of intervention, including beginning with referential structured input activities that have correct or incorrect answers, followed by affective structured input activities, which are more open-ended and allow for student creativity. Also, it is noted that learners are not tested on rules, but rather successful comprehension/ meaningful processing is emphasized. The chapter concludes with a dis-cussion on why this type of intervention aids the development of relevant mental representations.

1.3.4   L2 vocabulary learning: insights from laboratory-based studies

In Chapter 9, Tokowicz and Degani selectively review research on adult L2 vocabulary learning, specifically focusing on the research from laboratory-based studies. They argue that vocabulary is a foundational part of L2 learning and organize their review into three sections. They first focus on instructional/training factors in terms of whether what is manipulated is the input to the learner (e.g., spacing, grouping vs. randomization of materials, and training form vs. meaning aspects of the representations), or the action taken by the learner (the keyword mnemonic, generation of material, and practice testing). Following this, stimulus factors are discussed, including form overlap/familiarity, word concreteness, and translation ambiguity. Then, learner factors are outlined in terms of learner memory capacity and bilingualism vs. monolingualism.

They conclude with a discussion of the relationship between studying naïve vs. ongoing learners on a language and argue that this distinction can be thought of as a continuum rather than a dichotomy. They propose a three-step sequence beginning with a well-controlled lab study with naïve learners, followed by a similar study with actual learners, and finally a study in a less-constrained environment with ongoing learners.

1.3.5   Usage-based acquisition and transfer

Ellis, Römer, and O'Donnell present in Chapter 10 an analysis of verb-argument constructions (VACs). The data presented support the idea that these constructions are learned from usage, but also that there is transfer from the L1 in the case of L2 speakers. The chapter details a study that first