Susanne Fuchs, Joanne Cleland, Amélie Rochet-Capellan

Preface

Learning and memory processes are basic features of human existence and are also reported in other species (Clayton & Dickinson, 1998). They allow us to (un)consciously adapt to changes in our social and physical environment in a variety of ways and may have been a precursor for survival in human evolution. Although learning and memory processes have been at the center of psychological, linguistic and philosophical research, and discussed from the earliest existence of these disciplines, there is still much to learn.

In the domain of speech production and perception, the focus of the present book, there has been a renaissance in terms of the subject's matter. Three major topics will be addressed in this book through reviewing previous work; discovering research gaps and summarizing potential future research directions; or with original work. These three major topics are: 1.) the role of real-time sensory (auditory) feedback for learning, 2.) the role of motor aspects for learning and memory (including recent technological developments which may support learning in people with specific needs) and 3.) representations in memory and the role of sleep on memory consolidation with a specific focus on second language learning.

Regarding the first topic, computational and technological developments in recent years have made it possible to alter sensory feedback of a speaker in *real-time*. That is, a speaker's spoken language can be recorded, manipulated, and played back with such a short delay that the speaker considers it as his/her own speech. These developments made it possible to investigate the role of auditory feedback in speech production and learning and determine how and when speakers adapt to changes in auditory feedback. The first two chapters of the book focus on this topic. Tiphaine Caudrelier and Amélie Rochet-Capellan provide a review of two decades of research initiated by Houde & Jordan's (1998) pioneering study on auditory-motor learning in response to formant perturbations. The chapter starts with an overview of the impact of Houde and Jordan's work across different research fields. Then, based on 77 studies using formant perturbations,

the authors present the systems and procedures associated with this paradigm. They also provide a comprehensive review of the research topics addressed by these studies and their main results. The chapter concludes with suggestions for future research, including using sensorimotor learning to further explore the nature of speech production representations.

The second chapter presents a recent study on real-time feedback perturbation by Eugen Klein, Jana Brunner, and Phil Hoole. They work on inter- and intra-individual variability of adaptation processes during auditory perturbation of vowel formants. Specifically, the authors investigate the influence of experimental task demands – such as the alternating perturbation of the second formant and the consonantal context of the perturbed vowel – on speakers' compensatory adjustments. Examining the adaptation process with due regard to its temporal dimension, the authors show that its variability is strongly associated with speakers' exploratory behavior and cannot be exclusively ascribed to the characteristics of speakers' internal models of speech motor control.

The next three chapters deal with the particular role of motor aspects in learning and memory consolidation. Different populations are investigated. In a review of literature on speech sound errors in people with autism, Louise McKeever, Joanne Cleland and Jonathan Delafield-Butt begin to explore the underlying causes of speech production differences in people with autism. Two major theoretical accounts for the prevalence of speech sound errors are highlighted: the speech attunement framework, and deficits in speech motor control. Both theories provide explanations for how children with autism may come to have difficulty learning to produce speech which is in line with their typically developing peers. The chapter concludes by suggesting that both the speech attunement framework and the theory of impaired speech motor control may be complimentary, rather than competing, theories and suggests further empirical work to test this assertion.

In the following chapter Joanne Cleland and James Scobbie focus on learning new speech motor plans in children with speech sound disorders. They first describe the concept of categorising persistent speech sound disorder in children as a disorder characterised by erroneous motor plans. They then go on to explain how various different forms of articulatory visual biofeedback (namely, electropalatography, electromagnetic

articulography and ultrasound tongue imaging) can be used to allow children to view their articulators moving in real time and use this information to establish more accurate motor plans. A novel theoretical account of how these articulatory biofeedback techniques might lead to establishment of new motor plans is given. The chapter concludes with an illustrative case study of a child with persistent velar fronting who acquired a new motor plan for velar stops using ultrasound visual biofeedback.

The role of motor aspects is then discussed by Marion Dohen, who provides a comprehensive review of the role of manual gestures in word learning and memorizing. Typically developing children as well as children with specific needs are the focus of this review. The findings from a selection of empirical studies serves for answering general questions about potential advantages, efficiency and types of manual gestures in learning novel words. Motor aspects of manual gestures, i.e. producing an additional gesture during learning is compared with findings where manual gestures are perceived only. Finally, Marion Dohen discusses three potential explanations as to why manual gestures might enhance learning novel words.

The last two chapters are dedicated to learning new languages and how this information is consolidated in memory. Starting in the early 90s of the last century there have been several theoretical and empirical attempts to justify that it is not abstract linguistic representations, but rather episodic traces (exemplars) that are stored in memory (see Smith 2015 for review). These may include fine phonetic detail, for example detail about the speaker's voice, the communicative situation and so on. More recently, these approaches have been unified to hybrid models, since neither the one nor the other can solely account for learning a language. Lisa Morano, Louis ten Bosch, and Mirjam Ernestus follow then with their work on different mental representations stored in memory. They place themselves in the Complementary Learning Systems framework which assumes the use of abstract and exemplar mental representations in speech comprehension. Specifically, their work focuses on second language (L2) listeners' exemplar representations of words. Their particular novel finding is that L2 exemplars are faithful representations of the speech signal. Thus, unlike abstract representations, exemplars have not been altered by listeners' L1 phonological filter. The authors also found significant evidence that L2

listeners used abstract representations in an experiment that had been specifically designed to trigger exemplar effects.

In the last twenty years, evidence has been accumulated that sleep may play a major role for memory. Pamela Fuhrmeister reviews some recent work suggesting that memory consolidation during sleep is important for non-native speech sound learning. While factors that influence learning of difficult speech sound contrasts have received a lot of attention in the literature, less is known about how what happens after learning can affect consolidation and retention of newly learned phonetic information. Studies from other domains, such as motor learning, are reviewed, and these suggest that certain tasks that follow training can interfere with consolidation of new information. Hints of these effects can already be found in studies in the speech domain, and the author argues that the sleep and memory consolidation literature should inform future speech research and that future research should consider not only how speech sounds are best learned, but also how they are most optimally consolidated and retained.

Besides the intellectual merit of the authors and reviewers, this book was only possible thanks to the financial support the French-German University (UFA) in Saarbrücken. They supported the publication of the book and the international winter school on "Speech production and perception: Learning and memory" that took place 2017 in Chorin, Germany. Furthermore, parts of the presented work were supported by a grant from the ANR-DFG to the Salammbo project (FU791/8-1). Finally, we would like to acknowledge all reviewers who helped improving clarity and structure of the chapters. We are very delighted that the Crowdfunding Initiative "Knowledge Unlatched" selected our book and allowed it to be open access. Thanks to all the unknown contributors!

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