Bridging the gap between phonetic abilities and the lexicon in second language learning

Miguel Llompart Garcia

München 2019

Bridging the gap between phonetic abilities and the lexicon in second language learning

Miguel Llompart Garcia

Inaugural-Dissertation
zur Erlangung des Doktorgrades der Philosophie
an der Ludwig–Maximilians–Universität
München

vorgelegt von
Miguel Llompart Garcia
aus Sóller

München, den 12.10.2018

Erstgutachter: PD Dr. habil. Eva Reinisch
Zweitgutachter: Prof. Dr. Jonathan Harrington
Tag der mündlichen Prüfung: 14.02.2019

A la meva mare

Acknowledgments

It is now time for all the people that made this dissertation possible to receive my most sincere 'Thank you'.

First and foremost, I would like to express my gratitude to my supervisor Eva Reinisch for her advice and continuous support throughout these years. She has been an example of motivation, critical thinking and commitment to scientific research from the very first day. Her invaluable guidance has helped me grow as a researcher enormously.

I thank Jonathan Harrington not only for his helpful advice on statistics and speech analysis techniques but also for his work as head of the Institute of Phonetics and Speech Processing. It has been a pleasure working side by side with such a great group of people, as has been being able to pick their brains at the various colloquia and workshops we all have attended together.

I am also grateful to my "Ph.D. sister" Nikola Eger. Thanks for all the talks, phonetics-related or not alike, and for all the times we had lunch together at the Schweinchenbau. Likewise, many thanks to Lia Saki Bucar and Pia Greca for sharing an office with me and not complaining too much. I also want to thank Jessica Siddins, Joseph Casillas and Christopher Carignan for their proofreading and the nice after-the-fact discussions.

Special thanks go to Miquel Simonet. He introduced me to the study of speech when I was still in Mallorca and then became a mentor and friend at the University of Arizona. Thanks also to my former colleagues at the UofA, who helped me get ready for my Ph.D. adventure.

Raquel, sobran las palabras. Después de miles de kilómetros hemos llegado hasta aquí. Muchas gracias por apoyarme siempre y por ayudarme a controlar los picos de estrés que han ido surgiendo en el camino, muchas veces —como tu bien dices— sin justificación alguna.

Finalment, moltes gràcies al meu pare Miquel, qui sap i fa tant que ni vint tesis doctorals li poden fer justícia, a la meva germana Margalida, qui constantment em sorprèn amb la seva maduresa i talent, i a la meva mare María del Carmen. Mamà, tu em vares ensenyar molt, entre d'altres coses que sempre he de donar tot el que tinc. Així ho he fet i així ho seguiré fent, doncs et duc gravada al cor.

Contents

Summary

When learning a language other than the native one later in life, the acquisition of some of its sounds can be extremely challenging. Especially problematic are cases in which two sound categories that are contrastive in the second language (L2) are close in the acoustic/perceptual space to the same native language (L1) category. This is the case of the English /ɛ/-/æ/ contrast for native speakers of German. In order for German learners of English to fully master a contrast like /ɛ/-/æ/, it is essential that two requirements are met. First, learners need to be able to perceive and produce each sound category as such, and not as the other member of the contrast (e.g., /æ/ as [æ] and not [ɛ]). Secondly, these sound categories must be correctly assigned to the L2 words that they should be a part of (e.g., /æ/ to *dragon* but not to *lemon*). Precisely, the main objective of this cumulative dissertation, consisting of three original empirical studies (presented in Chapters 2, 3 and 4), was to investigate the interplay between these two requirements; That is, the relationship between the accurate perception and production of English /ɛ/ and /æ/ (i.e., *phonetic abilities*) and the robust and consistent phonological encoding of these sounds to English lexical representations (i.e., *lexical encoding*) for German learners of English.

The first study (Chapter 2) was concerned with the imitation of the challenging /ɛ/-/æ/ contrast plus a control contrast that is shared by German and English (/i/-/ɪ/). The main focus lay on whether the imitation patterns of German learners of English (in an explicit imitation task) related to their ability to perceptually identify these sounds (in a perceptual categorization task) and to their actual production of the same sounds in L2 words (in a word reading task). Results showed that the learners' productions of /ɛ/ and /æ/ in the imitation task related to their perceptual categorization patterns for that contrast but, crucially, not to their productions of the two vowels when reading L2 words aloud. While in the imitation task learners were able to differentiate the two sounds in their productions, in the word reading task, /æ/ was generally produced with acoustic properties approximating those of /ɛ/. This strongly suggests that, even though learners can produce /æ/ as a distinct L2 sound under some circumstances, their encoding of this category into /æ/-words (e.g., *fact*, *hammer*) is still rather deficient. These results mirror, in the production domain,

previous findings in perception, where considerable difficulties in lexical recognition have been documented in spite of an accurate perceptual identification of sounds in difficult L2 contrasts.

The second study (Chapter 3) investigated whether the robust encoding of sounds in L2 contrasts into lexical representations is related to how flexible (or not) learners are with these contrasts in phonetic perception. The lexical encoding of the /ɛ/-/æ/ and /i/-/ɪ/ English contrasts (like in the previous study) was assessed by means of a lexical decision task containing within-contrast mispronunciations (e.g., *lemon* as *l[æ]mon and *dragon* as *dr[ɛ]gon). To quantify perceptual flexibility, a distributional learning task on acoustic continua corresponding to the two contrasts was used. Individual performances in the two tasks were compared separately for each contrast. The main finding was that only for the difficult /ɛ/-/æ/ contrast could a relationship be captured. More precisely, the better learners were in lexical decision, the less they shifted their perceptual boundary between the two sounds in distributional learning. Hence, this study was able to identify yet another phonetic ability (i.e., perceptual flexibility/rigidity) that plays a prominent role in the lexical encoding of difficult L2 sounds. Furthermore, the fact that rigidity in perception with /ɛ/-/æ/ is associated with better lexical performance critically suggests that perceptual flexibility, which is known to be beneficial in first-language listening, may not be desirable when it comes to problematic non-native categories.

The third study (Chapter 4) also examined the encoding of the English /ɛ/-/æ/ contrast in L2 lexical representations for German learners of English. However, it used a novel-word learning (i.e., training) paradigm in order to probe the establishment of new L2 lexical representations containing the critical sounds (e.g., *tenzer-tandek*). The main research question of this study was whether exposure to additional information about the articulatory properties of /ɛ/ and /æ/ during training would facilitate the encoding of /ɛ/ and /æ/ as two different categories in the novel L2 words. In addition to a baseline group that learned the words by means of auditory stimuli only (Audio condition), two other comparable groups of learners obtained articulatory information coming from one of two different sources: (i) passive exposure to the mouth and jaw movements of a native speaker presented via audiovisual stimuli (Video condition), and (ii) active articulation of the target words when repeating the critical stimuli aloud (Repetition condition). After training, their online recognition of the novel words was probed in a visual world eye-tracking task. Analyses of eye-gaze patterns showed that learners in both the Video and the Repetition condition, but not those in the Audio condition, had effectively encoded /ɛ/ and /æ/ as two different categories in these newly-established lexical representations, as evidenced by the differential fixation patterns to novel words with the two vowels. Therefore, this study showed that phonetic, production-related information obtained during word learning can

have a positive impact on how robustly the sounds in a difficult L2 contrast are encoded into novel L2 lexical items.

Two main conclusions can be drawn from the work in this dissertation. First, the studies in Chapters 2 and 3 provide further evidence, from both non-native perception and production, that that there is indeed a very large gap between L2 learners' performance with difficult L2 contrasts in tasks taping into phonetic abilities and tasks involving accessing lexical representations. Secondly, and most importantly, the findings in Chapters 3 and 4 show that the lexical encoding of sounds in difficult L2 contrasts is a complex and multifaceted process that is conspicuously modulated by one's phonetic abilities, as well as by the information that is available at the very moment of word learning.

Chapter 1

Introduction

Starting to learn a second language (L2) later in life translates into difficulties at many levels. For example, learners frequently struggle to acquire the syntactic structures and to grasp the patterning of the morphological rules of a non-native language (see DeKeyser, 2005 for a review). Similarly, learning certain new lexical items can be a real challenge (Pajak, Creel, & Levy, 2016), as it can be tuning into the pragmatic subtleties of the language to be learned (Bardovi-Harlig & Vellenga, 2012). However, among all the difficulties faced by L2 learners, few are more notorious than those related to the acquisition of the sounds of the new language, which usually translate into learners exhibiting noticeable foreign accents and being involved in miscommunications much more often than native speakers (e.g., Broersma, 2005; Broersma & Cutler, 2008; Eger & Reinisch, 2017; Flege, 1988; Munro & Derwing, 2002; Pallier, Colomé, & Sebastián-Gallés, 2001; Piske, MacKay, & Flege, 2001; Porretta, Tucker, & Järvikivi, 2016; Weber & Cutler, 2004).

Most models of L2 phonetic acquisition agree in that difficulties with L2 sounds are largely determined by the disposition of the sound inventories of the native language (L1) and the language to be learned. For late learners, the L1 has frequently been described as acting like a sieve that modulates how the sounds of the L2 are perceived and produced (Best & Tyler, 2007; Flege, 1995; Trubetzkoĭ, 1977). According to Flege's (1995) *Speech Learning Model* (SLM), when an L2 sound is distant in the phonetic space from the existing L1 categories, learning to perceive and produce such sound should be uncomplicated. The closer or more similar the L2 sound is to an already established L1 category, however, the more difficult its learning as a new non-native category is expected to be. This similarity is especially problematic in cases in which there is more than one L2 sound in the proximity of an L1 category. Likewise, Best and Tyler's (2007) *Perceptual Assimilation Model-L2* (PAM L2) argues that the most difficulties in L2 sound category learning are observed when two sounds that are contrastive in the L2 are consistently mapped onto or assimilated to

the same L1 category, a situation that they labelled as *single-category assimilation*. Well known examples of L2 sound distinctions that correspond to the single-category assimilation pattern are, for instance, English /l/ and /r/ for native speakers of Japanese (Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004; Goto, 1971; Sheldon & Strange, 1982) and the English vowel contrast /ɛ/-/æ/ for Dutch and German speakers (Bohn & Flege, 1990; Broersma, 2005, 2012; Escudero, Hayes-Harb, & Mitterer, 2008; Flege, Bohn, & Jang, 1997).

A considerable amount of research suggests that mismatches in L1-L2 sound inventory relationships that result in single-category assimilations pose difficulties to learners at two interconnected levels. First, there are the difficulties at the sound or phonetic category level, that is, the inability, at least in the early stages of learning, to accurately perceive and produce the acoustic distinction between the sounds. These difficulties can be clearly observed when learners are asked to identify the sounds in perceptual tasks or prompted to produce the intended categories (Bohn & Flege, 1990, 1992; Bradlow, Pisoni, Akahane-Yamada, & Tohkura, 1997; Escudero & Boersma, 2004; Flege, 1995; Flege et al., 1997; Flege, MacKay, & Meador, 1999; Flege, Takagi, & Mann, 1995; Ingram & Park, 1997; Iverson & Evans, 2007). Secondly, these inaccuracies at the phonetic category level have a major impact on how learners represent and process words containing problematic L2 sounds, that is, how they perform with these sounds at the lexical (i.e., word) level.

Difficulties to distinguish between two (or more) L2 sounds in perception and production can have a strong impact on how accurately words containing these sounds are represented in the learners' mental lexicon, as well as on how easily such words are recognized when listening to L2 speech (Broersma, 2005, 2012; Broersma & Cutler, 2008, 2011; Cutler, Weber, & Otake, 2006; Sebastián-Gallés & Baus, 2005; Sebastián-Gallés, Echeverría, & Bosch, 2005; Weber, Broersma, & Aoyagi, 2011; Weber & Cutler, 2004). Importantly, research has shown that learners' performance at the phonetic category level is related to performance at the lexical level but also that there can be considerable mismatches between the two (Broersma, 2005, 2012; Darcy, Daidone, & Kojima, 2013; Darcy et al., 2012; Díaz, Mitterer, Broersma, & Sebastián-Gallés, 2012; Silbert et al., 2015; Simonchyk & Darcy, 2017, 2018). Consequently, using the English /ɛ/-/æ/ contrast and native speakers of German as a testing ground, the major aim of this dissertation is to reach a better characterization of the relationship between L2 learners' phonetic abilities with challenging non-native sound contrasts and the encoding of these sounds into individual lexical entries in the L2 (i.e. (phono)lexical encoding). *Phonetic abilities* can be broadly described as the capability to perceive and produce a specific sound category as such, and not as the other member of the contrast (e.g., /æ/ as [æ] and not [ɛ]), whereas *lexical encoding* refers to the correct

assignment of these sound categories as one of the phonological units making up the lexical representations of concrete L2 words (e.g., /æ/ as being part of *dragon* but not of *lemon*).

1.1 Difficulties at the sound level and the perception-production link

In perception, L2 sounds in a single-category assimilation pattern (Best & Tyler, 2007) are very difficult to distinguish for learners, who perceive both of them as being members of the same L1 category. For the contrast and population of interest, English /ɛ/ is commonly mapped to the native German sound /ɛ/ because the two categories are acoustically and perceptually similar. However, English /æ/, which does not exist in German and needs to be established as a new L2 category, is also mapped onto the same German vowel. This two-to-one mapping makes the perceptual distinction between the two sounds very difficult: while English /ɛ/ is consistently identified as /ɛ/, /æ/, which is a worse fit to the native category, is often also mistakenly perceived as /ɛ/ (Bohn & Flege, 1990). A recurrent finding is, however, that learners' perceptual abilities with this type of contrasts improve with L2 experience. For instance, Flege et al. (1997) found that German learners who had been long living an in English-speaking country were much more accurate in perceiving the /ɛ/-/æ/ distinction than learners with limited experience in an L2-speaking environment.

Difficulties in phonetic perception are typically linked to similar problems in production. The two contrasting L2 sounds are often not differentiated in production because they are both produced similarly to the corresponding L1 category. In the case of /ɛ/-/æ/, German learners of English produce /ɛ/ similarly to native English speakers because English and German /ɛ/ are articulated fairly similarly. However, /æ/ is also often produced in a similar fashion to /ɛ/ (Flege et al., 1997). Just as in perception, once again it is the L2 category that is a worse fit to the L1 that is most problematic for non-native speakers. Nonetheless, with extensive experience with the L2, accurate phonetic (i.e., acoustic) separation between the two sounds can be achieved. In fact, sometimes productions by L2 learners can successfully approximate those of native speakers (Bohn & Flege, 1992; Flege, Takagi, & Mann, 1995).

A key empirical question with regard to L2 phonetic abilities is how perception and production interact during L2 sound category learning, since in order to fully master the sounds of the non-native language, both the perception and production of sounds in difficult L2 contrasts, like /ɛ/-/æ/ for German learners of English, need to improve to the point in which the two sounds are reliably distinguished. This connection has been looked into

in several different ways. First, there are studies that sought to find a relationship at the individual level between performance in perception and production tasks with L2 sounds that are typically challenging for a given learner population (Bent, 2005; de Jong, Hao, & Park, 2009; Peperkamp & Bouchon, 2011). That is, learners were asked to perceptually identify and produce specific L2 sounds and then individual values were compared between the two modalities. Secondly, another common approach has been to train learners to either perceive or produce L2 categories and then assess whether improvements in the trained modality transferred to the other modality and, if so, under what circumstances (Akahane-Yamada, McDermott, Adachi, Kawahara, & Pruitt, 1998; Bradlow, Akahane-Yamada, Pisoni, & Tohkura, 1999; Bradlow et al., 1997; Hirata, 2004; Lopez-Soto & Kewley-Port, 2009b; Thorin, Sadakata, Desain, & McQueen, 2018; Wong, 2013). Finally, learners' imitation of non-native sounds after hearing a native speaker model has also been used as a window to the link between L2 perception and production (de Jong et al., 2009; Flege & Eefting, 1988; Hao & de Jong, 2016; Jia, Strange, Wu, Collado, & Guan, 2006; Rojczyk, 2013; Rojczyk, Porzuczek, & Bergier, 2013; Schouten, 1977). Importantly, imitation tasks are considered to be especially informative regarding the interplay between perception and production because imitating involves the engagement and coordination of the two systems along the way.

Studies involving the imitation of L2 sounds have rendered somehow mixed results with regards to the perception-production link. Studies examining a large variety of L2 sounds (including both unproblematic and new, challenging L2 categories in their design) have reported that the acoustic characteristics of the productions elicited through imitation corresponded with the listeners perceptual categorization patterns for the same L2 sounds (Flege & Eefting, 1988; Jia et al., 2006; Schouten, 1977). This points towards a tight relationship between perceptual categorization and production in imitation. However, when this type of tasks focused on difficult-to-acquire L2 sounds and sound distinctions, it has been found that learners are often better able to produce these categories when imitating a native model than when producing them by themselves, such as when reading aloud (Hao & de Jong, 2016; Rojczyk, 2013; Rojczyk et al., 2013). This raises the question as to whether imitation of difficult L2 sounds differs from imitation of other less problematic categories, and if so, what these differences mean for the perception-production link in L2 phonetic learning. Chapter 2 in this thesis touches upon these issues by examining how perception, imitation and production abilities (in word reading) relate within the individual German learner of English for the difficult /ɛ/-/æ/ contrast and another L2 contrast deemed to be easier.

1.2 Difficulties at the word level: lexical encoding

Late learners not only experience difficulties with specific L2 sounds, be it with perceiving them correctly or producing them distinctively. They also often struggle to establish robust lexical (i.e., word) representations in the non-native language. Part of the problem directly stems from the relatively impoverished input late-learners usually receive in the L2. Vocabulary size in the L2 is relatively small when compared to the L1 at almost any point in the learning process (Bundgaard-Nielsen, Best, & Tyler, 2011; Nation, 2006; Webb, 2008), which means that fewer words are stored in the L2 lexicon and therefore fewer items are becoming fully integrated into long-term memory (Gollan, Montoya, Cera, & Sandoval, 2008). In addition to this, learners' limited experience with the L2 results in that, for words that do become stored in the lexicon, lexical representations generally lack relevant detail about the individual sounds making up the word. That is, phonetic-phonological information is not encoded into such representations with the same robustness as it is in native representations (e.g., Cook, Pandža, Lancaster, & Gor, 2016).

On top of this, the perception and production difficulties with specific L2 sounds discussed above act as an additional obstacle to the establishment of phonologically robust lexical representations. Note that, to fully master difficult L2 sound contrasts, learners not only need to differentiate the sounds in the contrast in perception and production. They also have to be able to link these sounds to the correct words stored in their L2 lexicon (e.g., for German speakers, /ɛ/ to *lemon* and *beg* and /æ/ to *dragon* and *bag*, and not the other way around). Importantly, these links need to be robust and reliable in order for learners to be able to recognize and produce L2 words correctly. Phonologically encoding sounds in difficult contrasts into lexical representations has been shown to be an extremely challenging task, above and beyond any difficulties learners experience at the sound level. Evidence of this is the fact that L2 learners perform poorly in word recognition tasks with words containing confusable L2 sounds even when their perceptual categorization of these sounds has already reached native-like levels (Broersma, 2005, 2012; Darcy et al., 2012; Sebastián-Gallés & Baus, 2005; Simon & Sjerps, 2017; Simon, Sjerps, & Fikkert, 2014; see Cutler, 2015 for a review). A likely explanation for this is that, even if learners can tease the two sounds apart in tasks focusing on phonetic perception, the distinction is not well represented in their lexicon: the phonetic-phonological information corresponding to sounds in difficult L2 contrasts is not robustly encoded into the lexical representations of words containing these sounds.

The representation of difficult L2 sounds and sound contrasts in the lexicon is usually assumed to relate to perceptual abilities at the sound level for these specific L2 categories (Broersma, 2005; Díaz et al., 2012; Nakai, Lindsay, & Ota, 2015; Pallier, Bosch, & Sebastián-

Gallés, 1997; Pallier et al., 2001; Sebastián-Gallés & Baus, 2005; Simon et al., 2014). This assumption is supported by recent evidence (Silbert et al., 2015; Simonchyk & Darcy, 2017) showing that listeners' ability to perceptually discriminate difficult non-native contrasts can moderately predict their success in learning and recognizing words containing the sounds in these contrasts. However, knowledge is still lacking about which specific perceptual abilities may be valuable in order to robustly encode difficult L2 sounds to lexical representations. Building on this, Chapter 3 in this thesis investigates whether robustness of lexical representations containing difficult L2 sounds is related to a phonetic ability in perception that has been shown to be prevalent and beneficial in L1 listening, but whose role in L2 learning is still not well understood: perceptual flexibility or adaptability.

1.3 Difficulties at the word level: spurious lexical competition

The generalized frailty of L2 lexical representations discussed in the previous section has negative consequences for spoken word recognition in the non-native language (Cook, 2012; Cook & Gor, 2015; Cook et al., 2016; Lancaster & Gor, 2016). When one listens to speech, lexical representations in the lexicon are activated. All words activated at the same time compete for recognition until the intended word is (generally) recognized. Crucially, the more words activated and competing for recognition, the more effortful it is to recognize the intended word (Broersma, 2005; McQueen, Norris, & Cutler, 1994). In the L2, listeners experience enhanced lexical competition due to various reasons. One of them is that word activation is strongly modulated by the attracting effect of native lexical representations: when listening to L2 speech, not only L2 words are activated, but also words of the L1 (Marian, Spivey, & Hirsch, 2003; Schulpen, Dijkstra, Schriefers, & Hasper, 2003; Spivey & Marian, 1999; Weber & Cutler, 2004). A paradigm that has commonly been used to examine lexical competition is visual world eye-tracking, where learners see pictures of objects on a computer screen while listening to auditory stimuli and their eye-gaze patterns are recorded while they decide which picture matches best with each auditory stimulus. Using this paradigm, Spivey and Marian (1999) showed that, when Russian learners of English heard English words, they temporarily looked at both the picture of the intended English target and the picture of a competitor object corresponding to a Russian word that was phonologically similar to the English target. For example, when hearing *marker*, they would fixate the picture of a stamp (*marku* in Russian) more than that of another unrelated English word like ruler (*lineika* in Russian).

Secondly, L2 learners suffer from enhanced lexical competition as a consequence of their suboptimal phonetic abilities with confusable L2 sounds and their weak phonological encoding of these sounds to their lexical representations, that is, the two issues covered in the preceding sections. A similar effect as that of L1 phonologically-related words was also found when learners were presented with L2 targets and competitors that overlapped in their first syllables except for one sound, which was one member of a difficult L2 contrast in one word and the other member of the contrast in the other word (Cutler et al., 2006; Escudero et al., 2008; Weber & Cutler, 2004). For example, Weber and Cutler (2004) showed that Dutch listeners, who have difficulties with the English /ɛ/-/æ/ contrast, temporarily fixated the picture of a *pencil* when asked to 'click on the *panda*'.

The examination of lexical competition patterns in visual world eye-tracking has greatly helped shed light on how the sounds in difficult L2 contrasts are represented in the lexicon. A relevant finding here is that lexical competition between words with sounds in difficult contrasts is not symmetrical. More competition (and therefore slower recognition) is observed for target words containing the sound of the contrast that is a worse match to a native category. Note that this parallels findings on L2 learners' performance in tasks focused on phonetic perception and production. Weber and Cutler (2004) reported that, while the auditory presentation of *panda* triggered looks to both *pencil* and *panda*, *pencil* was fixated rapidly and with minimal interference from *panda*. Similar asymmetric patterns in lexical tasks have been shown with native English speakers for other contrasts, like /t/-/tt/ in Japanese (Hayes-Harb & Masuda, 2008) and /y/-/u/ in German (Darcy et al., 2013). These differential recognition patterns have been taken to indicate that difficult L2 contrasts are phonologically encoded in the lexicon as an asymmetric distinction between the dominant category in the contrast ("Category X") and a fuzzy category that is not the dominant one ("Category not-X"; Hayes-Harb & Masuda, 2008). In the case of /ɛ/-/æ/, for German learners of English, the less problematic vowel /ɛ/ is therefore assumed to be more easily and more robustly encoded into the corresponding L2 words (e.g., *lemon*) than /æ/ (e.g., *dragon*).

Interestingly, Cutler et al. (2006) claimed that the encoding of these difficult contrasts to lexical entries can be affected by factors such as explicit instruction on the phonetic properties of the L2 and the mapping of the sounds in the contrast to L2 orthography. Indeed, Escudero et al. (2008) provided evidence that orthography can play a significant role in the encoding of L2 contrasts to the lexicon. Lexical competition patterns for Dutch listeners with the English /ɛ/-/æ/ contrast were examined using a paradigm similar to that in Weber and Cutler (2004). Instead of using real words, however, Escudero et al. (2008) trained listeners to learn novel words (e.g., *tenzer-tandek*), ensuring thus that learners did not know their spelling beforehand. Dutch participants were assigned to one of two training

conditions, either an audio-only condition or a condition in which they heard the novel words together with their orthographic representations. After training, recognition of the novel words was tested in a visual world eye-tracking task. Results showed that fixation patterns of the group additionally exposed to orthography differentiated the vowels in the same way as reported in Weber and Cutler (2004) for real English words. The audio-only group, on the contrary, showed strong competition that was symmetrical between words with the two vowels in the contrast until they processed the disambiguating second syllable of the words. The authors concluded that information that is additional to the signal (i.e., orthography) can be used on the spot by learners to establish a distinction between the confusable L2 sounds in the novel words newly-established in the lexicon. What still remains to be seen is whether other types of information may also facilitate the encoding of such non-native distinctions to the L2 lexicon. Particularly interesting for the main question with which this dissertation is concerned is whether information on the phonetic properties of the critical sounds may be used to rapidly and accurately encode such as distinction in the lexicon and use it productively in spoken word recognition. Chapter 4 sheds light on this issue by testing the potential effects on the establishment of the /ɛ/-/æ/ distinction in novel English words for German learners of English of two types of information related to L2 production: visual articulatory information (i.e., jaw and lip movements) and own articulation (i.e., repetition after a native model).

1.4 Overview of the thesis

This is a cumulative dissertation that consists of three original empirical studies corresponding to Chapters 2, 3 and 4. The main objective of this work is to investigate the relationship between the perception and production abilities of late L2 learners (i.e., German learners of English) with a challenging non-native sound contrast (English /ɛ/-/æ/) and the encoding of this contrast into the word-sized representations contained in their L2 lexicon. Using a variety of experimental methods, several key questions (listed below) are addressed regarding the connection between the establishment (or not) of well-defined sound categories for the sounds in such difficult-to-acquire L2 contrast and the accurate and consistent linking of such sound categories to individual lexical entries in the L2. Importantly, the focus of a number of experiments in this thesis does not only lie on L2 learners as a group. Instead, by favoring by-participant measures and performing analyses aimed at characterizing individual differences, this work also attempts to provide insights on how the relationship of interest manifests itself at the level of the individual.

Chapter 2 focuses on the study of L2 learners' phonetic imitation abilities for two contrasts differing in their degree of difficulty for our population of interest. That is, the challenging /ɛ/-/æ/ contrast and a contrast that is also present in the learners' L1 (/i/-/ɪ/). Even though imitation is frequently seen as central in language acquisition (e.g., Masur, 1995; Tomasello, 1992), it remains largely understudied within the scope of second language sound category learning (but see Flege & Eefting, 1988; Hao & de Jong, 2016). Consequently, Chapter 2 attempts to reach a better understanding of L2 phonetic imitation by probing the link between imitation and the learners' perception and production abilities for the same L2 categories. Individual performance in an imitation task in which learners are asked to imitate the steps of two continua (one per contrast) is therefore compared to performance in a perceptual identification task and a word reading task, respectively. With these comparisons, the two following questions are investigated: i) to what extent does imitation relate to the state of the imitated categories in the learner's L2 sound system? And ii) does imitative performance match with how these categories are productively used by the learner in L2 words? Crucially, this last question speaks to the main topic of the thesis because it involves the comparison of the individual learners' productions in a task that is phonetically-oriented and hardly relies on lexical information (i.e., imitation) to productions in a task with a higher lexical involvement (i.e., word reading). This allows for the examination of the potential impact of the L2 lexicon, and in particular of non-native-like (i.e., fuzzy) lexical representations for words containing the sounds of the difficult contrast, on the production of the target L2 sounds.

In Chapter 3, the focus lies on the relationship between learners' phonetic perception of L2 contrasts and the representation of these contrasts in words in the L2 lexicon. More specifically, this chapter investigates whether a relationship can be found between a robust phonological encoding of sounds in L2 contrasts into lexical representations and perceptual flexibility (or a lack thereof) with these contrasts at the phonetic level. This relationship is assessed for the same English vowel contrasts as in Chapter 2. Previous research has shown that L2 learners can shift their perceptual boundaries between L2 categories that are not perceptually confusable in order to adapt to anomalous productions of these sounds (Reinisch, Weber, & Mitterer, 2013; Schuhmann, 2014). However, for L2 contrasts that are challenging both at the phonetic and lexical level, there is partial evidence suggesting that flexibility with these phonetic distinctions may not be beneficial but costly (Sjerps & McQueen, 2010).

The robustness of (phono)lexical encoding of the two L2 contrasts is assessed using a lexical decision task containing mispronunciations. This means that some words containing /ɛ/ are presented as produced with [æ], and some words that have /æ/ are presented containing [ɛ] (e.g., *lemon* as *l[æ]mon and *dragon* as *dr[ɛ]gon), and the same for /i/-/ɪ/.

Phonetic flexibility for these same contrasts is investigated by means of a distributional learning task. In this task, learners are asked to perceptually categorize continua for the two key contrasts. Critically, categorization phases are always preceded by exposure phases designed to bias perception towards one of the response options during categorization. If listeners' perception of the categories in a given contrast is flexible, then they are expected to show adaptation to such bias and shift their category boundary accordingly. Individual performance in the two tasks is subsequently compared, separately for each of the two contrasts, in order to discern whether proficiency with the L2 contrast at the lexical level (as an indicator of robust lexical encoding) is indeed related (and if so, how) to a phonetic ability, perceptual flexibility, which is central to speech perception but whose role concerning challenging L2 sound distinctions remains unclear.

Chapter 4 is concerned with the relationship between the articulation/production of L2 categories and the encoding of these categories into lexical representations in the non-native language. In particular, it assesses whether learners benefit from obtaining information additional to the acoustic signal about the articulatory properties of /ɛ/ and /æ/ when learning novel L2 words containing these two sounds. Previous studies showed that learners can indeed use the sounds in challenging L2 contrasts to distinguish between words, as evidenced by asymmetries in word recognition (Cutler et al., 2006; Weber & Cutler, 2004). It has been argued that factors external to the learners' base phonetic abilities play a role in the encoding of difficult distinctions onto individual L2 words, which has been partially confirmed by a study showing that orthographic knowledge helps establish a distinction in non-native novel words between the categories in a challenging L2 contrast (Escudero et al., 2008). In the experiments in this chapter, learners are trained to learn novel English words (e.g., *tenzer-tandek*) with different types of input, and their recognition of the novel words is subsequently tested in a visual world eye-tracking task. In Experiment 1, a baseline group is exposed to the words audio-only during training, while learners in another group additionally see videos of the speaker articulating the target words. In Experiment 2, learners are asked to repeat the target words themselves as part of their training. The main question is whether learners will be able to use the additional knowledge about the articulation of the two critical sounds, acquired through either passive exposure to visual information (Experiment 1) or their own active articulation of the words (Experiment 2), to distinguish between the vowels in the newly-established lexical representations of the novel words.

References

Akahane-Yamada, R., McDermott, E., Adachi, T., Kawahara, H., & Pruitt, J. S. (1998). Computer-based second language production training by using spectrographic representation and HMM-based speech recognition scores. In R. H. Mannell & J. Robert-Ribes (Eds.), *Proceedings of International Conference on Spoken Language Processing (ICSLP)* (pp. 1– 4). Canberra, Australia: Australian Speech Science and Technology Association, Incorporated (ASSTA).

Aoyama, K., Flege, J. E., Guion, S. G., Akahane-Yamada, R., & Yamada, T. (2004). Perceived phonetic dissimilarity and L2 speech learning: The case of Japanese /r/ and English /l/ and /r/. *Journal of Phonetics*, *32*, 233–250. https://doi.org/10.1016/S0095-4470(03)00036-6

Bardovi-Harlig, K., & Vellenga, H. E. (2012). The effect of instruction on conventional expressions in L2 pragmatics. *System*, *40*(1), 77–89. https://doi.org/10.1016/j.system.2012.01.004

Bent, T. (2005). *Perception and production of non-native prosodic categories* (PhD thesis). Evanston, IL: Northwestern University.

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In O. S. Bohn & M. J. Munro (Eds.), *Language experience in second language speech learning: In honor of James Emil Flege* (pp. 13–34). Amsterdam, the Netherlands: John Benjamins. https://doi.org/10.1075/lllt.17.07bes

Bohn, O.-S., & Flege, J. E. (1990). Interlingual identification and the role of foreign language experience in L2 vowel perception. *Applied Psycholinguistics*, *11*(3), 303–328. https://doi.org/10.1017/S0142716400008912

Bohn, O.-S., & Flege, J. E. (1992). The production of new and similar vowels by adult German learners of English. *Studies in Second Language Acquisition*, *14*(2), 131–158. https://doi.org/10.1017/S0272263100010792

Bradlow, A. R., Akahane-Yamada, R., Pisoni, D. B., & Tohkura, Y. I. (1999). Training Japanese listeners to identify English /r/ and /l/: Long-term retention of learning in perception and production. *Perception & Psychophysics*, *61*(5), 977–985. https://

doi.org/10.3758/BF03206911

Bradlow, A. R., Pisoni, D. B., Akahane-Yamada, R., & Tohkura, Y. I. (1997). Training Japanese listeners to identify English /r/ and /l/: IV. Some effects of perceptual learning on speech production. *The Journal of the Acoustical Society of America*, *101*(4), 2299–2310. https://doi.org/10.1121/1.418276

Broersma, M. (2005). *Phonetic and lexical processing in a second language* (PhD thesis). Nijmegen, The Netherlands: Radboud University.

Broersma, M. (2012). Increased lexical activation and reduced competition in second-language listening. *Language and Cognitive Processes*, *27*(7-8), 1205–1224. https://doi.org/10.1080/01690965.2012.660170

Broersma, M., & Cutler, A. (2008). Phantom word activation in L2. *System*, *36*(1), 22–34. https://doi.org/10.1016/j.system.2007.11.003

Broersma, M., & Cutler, A. (2011). Competition dynamics of second-language listening. *Quarterly Journal of Experimental Psychology*, *64*(1), 74–95. https://doi.org/10.1080/17470218.2010.499174

Bundgaard-Nielsen, R. L., Best, C. T., & Tyler, M. D. (2011). Vocabulary size is associated with second-language vowel perception performance in adult learners. *Studies in Second Language Acquisition*, *33*(3), 433–461. https://doi.org/10.1017/S0272263111000040

Cook, S. V. (2012). *Phonological form in L2 lexical access: Friend or foe?* (PhD thesis). College Park, MD: University of Maryland.

Cook, S. V., & Gor, K. (2015). Lexical access in L2: Representational deficit or processing constraint? *The Mental Lexicon*, *10*(2), 247–270. https://doi.org/10.1075/ml.10.2.04coo

Cook, S. V., Pandža, N. B., Lancaster, A. K., & Gor, K. (2016). Fuzzy nonnative phonolexical representations lead to fuzzy form-to-meaning mappings. *Frontiers in Psychology*, *7*, 1345. https://doi.org/10.3389/fpsyg.2016.01345

Cutler, A. (2015). Representation of second language phonology. *Applied Psycholinguistics*, *36*(1), 115–128. https://doi.org/10.1017/S0142716414000459

Cutler, A., Weber, A., & Otake, T. (2006). Asymmetric mapping from phonetic to lexical representations in second-language listening. *Journal of Phonetics*, *34*(2), 269–284. https://doi.org/10.1016/j.wocn.2005.06.002

Darcy, I., Daidone, D., & Kojima, C. (2013). Asymmetric lexical access and fuzzy lexical representations in second language learners. *The Mental Lexicon*, *8*(3), 372–420. https://doi.org/10.1075/ml.8.3.06dar

Darcy, I., Dekydtspotter, L., Sprouse, R. A., Glover, J., Kaden, C., McGuire, M., & Scott, J. H. (2012). Direct mapping of acoustics to phonology: On the lexical encoding of front

rounded vowels in L1 English–L2 French acquisition. *Second Language Research*, *28*(1), 5–40. https://doi.org/10.1177/0267658311423455

de Jong, K., Hao, Y. C., & Park, H. (2009). Evidence for featural units in the acquisition of speech production skills: Linguistic structure in foreign accent. *Journal of Phonetics*, *37*(4), 357–373. https://doi.org/10.1016/j.wocn.2009.06.001

DeKeyser, R. M. (2005). What makes learning second-language grammar difficult? A review of issues. *Language Learning*, *55*(S1), 1–25. https://doi.org/10.1111/j.0023-8333.2005.00294.x

Díaz, B., Mitterer, H., Broersma, M., & Sebastián-Gallés, N. (2012). Individual differences in late bilinguals' L2 phonological processes: From acoustic-phonetic analysis to lexical access. *Learning and Individual Differences*, *22*(6), 680–689. https://doi.org/10.1016/j.lindif.2012.05.005

Eger, N. A., & Reinisch, E. (2017). The role of acoustic cues and listener proficiency in the perception of accent in non-native sounds. *Studies in Second Language Acquisition*, 1–22. https://doi.org/10.1017/s0272263117000377

Escudero, P., & Boersma, P. (2004). Bridging the gap between L2 speech perception research and phonological theory. *Studies in Second Language Acquisition*, *26*(4), 551–585. https://doi.org/10.1017/S0272263104040021

Escudero, P., Hayes-Harb, R., & Mitterer, H. (2008). Novel second-language words and asymmetric lexical access. *Journal of Phonetics*, *36*(2), 345–360. https://doi.org/10.1016/j.wocn.2007.11.002

Flege, J. E. (1988). Factors affecting degree of perceived foreign accent in English sentences. *The Journal of the Acoustical Society of America*, *84*(1), 70–79. https://doi.org/10.1121/1.396876

Flege, J. E. (1995). Second language speech learning: Theory, findings and problems. In W. Strange (Ed.), *Speech perception and linguistic experience. Issues in cross-language research* (pp. 233–277). Timonium, MD: York Press.

Flege, J. E., Bohn, O.-S., & Jang, S. (1997). Effects of experience on non-native speakers' production and perception of English vowels. *Journal of Phonetics*, *25*(4), 437–470. https://doi.org/10.1006/jpho.1997.0052

Flege, J. E., & Eefting, W. (1988). Imitation of a VOT continuum by native speakers of English and Spanish: Evidence for phonetic category formation. *The Journal of the Acoustical Society of America*, *83*(2), 729-740. https://doi.org/10.1121/1.396115

Flege, J. E., MacKay, I. R. A., & Meador, D. (1999). Native Italian speakers' perception and production of English vowels. *The Journal of the Acoustical Society of America*, *106*(5), 2973–2987. https://doi.org/10.1121/1.428116

Flege, J. E., Takagi, N., & Mann, V. (1995). Japanese adults can learn to produce English

/r/ and /l/ accurately. *Language and Speech*, *38*(1), 25–55. https://doi.org/10.1177/002383099503800102

Gollan, T. H., Montoya, R. I., Cera, C., & Sandoval, T. C. (2008). More use almost always means a smaller frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of Memory and Language*, *58*(3), 787–814. https://doi.org/10.1016/j.jml.2007.07.001

Goto, H. (1971). Auditory perception by normal Japanese adults of the sounds "L" and "R". *Neuropsychologia*, *9*(3), 317–323. https://doi.org/10.1016/0028-3932(71)90027-3

Hao, Y.-C., & de Jong, K. (2016). Imitation of second language sounds in relation to L2 perception and production. *Journal of Phonetics*, *54*, 151–168. https://doi.org/10.1016/j.wocn.2015.10.003

Hayes-Harb, R., & Masuda, K. (2008). Development of the ability to lexically encode novel second language phonemic contrasts. *Second Language Research*, *24*, 5–33. https://doi.org/10.1177/0267658307082980

Hirata, Y. (2004). Computer assisted pronunciation training for native English speakers learning Japanese pitch and durational contrasts. *Computer Assisted Language Learning*, *17*(3-4), 357–376. https://doi.org/10.1080/0958822042000319629

Ingram, J. C., & Park, S.-G. (1997). Cross-language vowel perception and production by Japanese and Korean learners of English. *Journal of Phonetics*, *25*(3), 343–370. https://doi.org/10.1006/JPHO.1997.0048

Iverson, P., & Evans, B. G. (2007). English vowel training with different first-language vowel systems. *The Journal of the Acoustical Society of America*, *121*(5), 3072–3072. https://doi.org/10.1121/1.4781875

Jia, G., Strange, W., Wu, Y., Collado, J., & Guan, Q. (2006). Perception and production of English vowels by Mandarin speakers: Age-related differences vary with amount of L2 exposure. *The Journal of the Acoustical Society of America*, *119*(2), 1118–1130. https://doi.org/10.1121/1.2151806

Lancaster, A., & Gor, K. (2016). Abstraction of phonological representations in adult nonnative speakers. *Proceedings of the Linguistic Society of America*, *1*, 24:1–15. https://doi.org/10.3765/plsa.v1i0.3725

Lopez-Soto, T., & Kewley-Port, D. (2009b). Relation of perception training to production of codas in English as a second language. *The Journal of the Acoustical Society of America*, *125*(4), 2756. https://doi.org/10.1121/1.4784637

Marian, V., Spivey, M., & Hirsch, J. (2003). Shared and separate systems in bilingual language processing: Converging evidence from eyetracking and brain imaging. *Brain and Language*, *86*(1), 70–82. https://doi.org/10.1016/S0093-934X(02)00535-7

Masur, E. (1995). Infants' early verbal imitation and their later lexical development. *Merrill-*

Palmer Quarterly, *41*(3), 286–306.

McQueen, J. M., Norris, D., & Cutler, A. (1994). Competition in spoken word recognition: Spotting words in other words. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(3), 621–638. https://doi.org/10.1037/0278-7393.20.3.621

Munro, M. J., & Derwing, T. M. (2002). Foreign accent, comprehensibility, and intelligibility in the speech of second language learners. *Language Learning*, *49*(s1), 285–310. https://doi.org/10.1111/0023-8333.49.s1.8

Nakai, S., Lindsay, S., & Ota, M. (2015). A prerequisite to L1 homophone effects in L2 spoken-word recognition. *Second Language Research*, *31*(1), 29–52. https://doi.org/10.1177/0267658314534661

Nation, I. S. P. (2006). How large a vocabulary is needed for reading and listening? *The Canadian Modern Language Review*, *63*(1), 59–82. https://doi.org/10.3138/cmlr.63.1.59

Pajak, B., Creel, S. C., & Levy, R. (2016). Difficulty in learning similar-sounding words: A developmental stage or a general property of learning? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*(9), 1377–1399. https://doi.org/10.1037/xlm0000247

Pallier, C., Bosch, L., & Sebastián-Gallés, N. (1997). A limit on behavioral plasticity in speech perception. *Cognition*, *64*(3), B9–B17. https://doi.org/10.1016/s0010-0277(97)00030-9

Pallier, C., Colomé, A., & Sebastián-Gallés, N. (2001). The influence of native-language phonology on lexical access: Exemplar-based versus abstract lexical entries. *Psychological Science*, *12*(6), 445–449. https://doi.org/10.1111/1467-9280.00383

Peperkamp, S., & Bouchon, C. (2011). The relation between perception and production in L2 phonological processing. In *Proceedings of the 12th Annual Conference of the International Speech Communication Association (Interspeech 2011)* (pp. 161–164). Rundle Mall, Australia: Causal Productions.

Piske, T., MacKay, I. R., & Flege, J. E. (2001). Factors affecting degree of foreign accent in an L2: A review. *Journal of Phonetics*, *29*(2), 191–215. https://doi.org/10.1006/jpho.2001.0134

Porretta, V., Tucker, B. V., & Järvikivi, J. (2016). The influence of gradient foreign accentedness and listener experience on word recognition. *Journal of Phonetics*, *58*, 1–21. https://doi.org/10.1016/j.wocn.2016.05.006

Reinisch, E., Weber, A., & Mitterer, H. (2013). Listeners retune phoneme categories across languages. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(1), 75–86. https://doi.org/10.1037/a0027979

Rojczyk, A. (2013). Phonetic imitation of L2 vowels in a rapid shadowing task. In J. Lewis &

K. LeVelle (Eds.), *Proceedings of the 4th Pronunciation in Second Language Learning and Teaching Conference* (pp. 66–76). Ames, IA: Iowa State University.

Rojczyk, A., Porzuczek, A., & Bergier, M. (2013). Immediate and distracted imitation in second-language speech: Unreleased plosives in English. *Research in Language*, *11*(1), 3–18. https://doi.org/10.2478/v10015-012-0007-7

Schouten, M. (1977). Imitation of synthetic vowels by bilinguals. *Journal of phonetics*, *5*(3), 273–283.

Schuhmann, K. S. (2014). *Perceptual learning in second language learners* (PhD thesis). State University of New York at Stony Brook.

Schulpen, B., Dijkstra, T., Schriefers, H. J., & Hasper, M. (2003). Recognition of interlingual homophones in bilingual auditory word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, *29*(6), 1155–1178. https://doi.org/10.1037/0096-1523.29.6.1155

Sebastián-Gallés, N., & Baus, C. (2005). On the relationship between perception and production in L2 categories. In A. Cutler (Ed.), *Twenty-first century psycholinguistics: Four cornerstones* (pp. 279–292). Hillsdale, NJ: LEA.

Sebastián-Gallés, N., Echeverría, S., & Bosch, L. (2005). The influence of initial exposure on lexical representation: Comparing early and simultaneous bilinguals. *Journal of Memory and Language*, *52*(2), 240–255. https://doi.org/10.1016/j.jml.2004.11.001

Sheldon, A., & Strange, W. (1982). The acquisition of /r/ and /l/ by Japanese learners of English: Evidence that speech production can precede speech perception. *Applied Psycholinguistics*, *3*(3), 243–261. https://doi.org/10.1017/S0142716400001417

Silbert, N. H., Smith, B. K., Jackson, S. R., Campbell, S. G., Hughes, M. M., & Tare, M. (2015). Non-native phonemic discrimination, phonological short term memory, and word learning. *Journal of Phonetics*, *50*, 99–119. https://doi.org/10.1016/J.WOCN.2015.03.001

Simon, E., & Sjerps, M. J. (2017). Phonological category quality in the mental lexicon of child and adult learners. *International Journal of Bilingualism*, *21*(4), 474–499. https://doi.org/10.1177/1367006915626589

Simon, E., Sjerps, M. J., & Fikkert, P. (2014). Phonological representations in children's native and non-native lexicon. *Bilingualism: Language and Cognition*, *17*(1), 3–21. https://doi.org/10.1017/S1366728912000764

Simonchyk, A., & Darcy, I. (2017). Lexical encoding and perception of palatalized consonants in L2 Russian. In *Proceedings of the 8th Pronunciation in Second Language Learning and Teaching Conference, INSS* (pp. 2380–9566).

Simonchyk, A., & Darcy, I. (2018). The effect of orthography on the lexical encoding of palatalized consonants in L2 Russian. *Language and Speech*, *61*(4), 522–546. https://

doi.org/10.1177/0023830918761490

Sjerps, M. J., & McQueen, J. M. (2010). The bounds on flexibility in speech perception. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(1), 195–211. https://doi.org/10.1037/a0016803

Spivey, M. J., & Marian, V. (1999). Cross talk between native and second languages: Partial activation of an irrelevant lexicon. *Psychological Science*, *10*(3), 281–284. https://doi.org/10.1111/1467-9280.00151

Thorin, J., Sadakata, M., Desain, P., & McQueen, J. M. (2018). Perception and production in interaction during non-native speech category learning. *The Journal of the Acoustical Society of America*, *144*(1), 92-103. https://doi.org/10.1121/1.5044415

Tomasello, M. (1992). The social bases of language acquisition. *Social Development*, *1*(1), 67–87. https://doi.org/10.1111/j.1467-9507.1992.tb00135.x

Trubetzkoĭ, N. S. (1977). *Grundzüge der Phonologie.* (6th ed.). Göttingen, Germany: Van den Hoeck & Ruprecht.

Webb, S. (2008). Receptive and productive vocabulary sizes of L2 learners. *Studies in Second Language Acquisition*, *30*(1), 79–95. https://doi.org/10.1017/S0272263108080042

Weber, A., Broersma, M., & Aoyagi, M. (2011). Spoken-word recognition in foreign-accented speech by L2 listeners. *Journal of Phonetics*, *39*(4), 479–491. https://doi.org/10.1016/j.wocn.2010.12.004

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language*, *50*(1), 1–25. https://doi.org/10.1016/S0749-596X(03)00105-0

Wong, J. W. S. (2013). The effects of perceptual and or productive training on the perception and production of English vowels /I/ and /i:/ by Cantonese ESL learners. In F. Bimbot et al. (Eds.), *Proceedings of the 14th Annual Conference of the International Speech Communication Association (Interspeech 2013)* (pp. 2113–2117). Lyon, France: ISCA.

Chapter 2

Perceptual categorization, imitation and word production

This chapter is published as:

Llompart, M. & Reinisch, E. (2018). Imitation in a second language relies on phonological categories but does not reflect the productive usage of difficult sound contrasts. *Language and Speech.* https://doi.org/10.1177/00238309-18803978

Abstract

This study investigated the relationship between imitation and both the perception and production abilities of second language (L2) learners for two non-native contrasts differing in their expected degree of difficulty. German learners of English were tested on perceptual categorization, imitation and a word reading task for the difficult English /ɛ/-/æ/ contrast, which tends not to be well encoded in the learners' phonological inventories, and the easy, near-native /i/-/ɪ/ contrast. As expected, within-task comparisons between contrasts revealed more robust perception and better differentiation during production for /i/-/ɪ/ than /ɛ/-/æ/. Imitation also followed this pattern, suggesting that imitation is modulated by the phonological encoding of L2 categories. Moreover, learners' ability to imitate /ɛ/ and /æ/ was related to their perception of that contrast, confirming a tight perception-production link at the phonological level for difficult L2 sound contrasts. However, no relationship was observed between acoustic measures for imitated and read-aloud tokens of /ɛ/ and /æ/. This dissociation is mostly attributed to the influence of inaccurate non-native lexical representations in the word reading task. We conclude that imitation is strongly related to the phonological representation of L2 sound contrasts, but does not need to reflect the learners' productive usage of such non-native distinctions.

Chapter 3

Phonetic flexibility and lexical representations

This chapter is published as:

Llompart, M. & Reinisch, E. (2018). Robustness of phonolexical representations relates to phonetic flexibility for difficult second language sound contrasts. *Bilingualism: Language and Cognition*, 1–16. https://doi.org/10.1017/S1366728918000925

Abstract

Listening to speech entails adapting to vast amounts of variability in the signal. The present study examined the relationship between flexibility for adaptation in a second language (L2) and robustness of L2 phonolexical representations. Phonolexical encoding and phonetic flexibility for German learners of English were assessed by means of a lexical decision task containing nonwords with sound substitutions and a distributional learning task, respectively. Performance was analyzed for an easy (/i/-/ɪ/) and a difficult contrast (/ɛ/-/æ/, where /æ/ does not exist in German). Results showed that for /i/-/ɪ/ listeners were quite accurate in lexical decision, and distributional learning consistently triggered shifts in categorization. For /ɛ/-/æ/, lexical decision performance was poor but individual participants' scores related to performance in distributional learning: the better learners were in their lexical decision, the smaller their categorization shift. This suggests that, for difficult L2 contrasts, rigidity at the phonetic level relates to better lexical performance.

Chapter 4

Articulatory information and novel lexical representations

This chapter is published as:

Llompart, M. & Reinisch, E. (2017). Articulatory information helps encode lexical contrasts in a second language. *Journal of Experimental Psychology: Human Perception and Performance, 43*(5), 1040–1056. https://doi.org/10-.1037/xhp0000383

Abstract

The present study examined whether obtaining additional articulatory information about the sounds of a difficult second language contrast (English /ɛ/-/æ/ for German speakers) could help non-native listeners to encode a lexical distinction between novel words containing these two categories. Novel words (e.g., *tenzer-tandek*) were trained with different types of input and their recognition was tested in a visual-world eye-tracking task. In Experiment 1, a baseline group was exposed to the words audio-only during training, while another group additionally saw videos of the speaker articulating the target words. In Experiment 2, listeners were asked to repeat the target words themselves as part of their training. It was found that both audiovisual input and word repetition during training resulted in asymmetric fixation patterns at test: words containing /ɛ/ were recognized more readily than those with /æ/, mirroring the recognition asymmetry reported for real English words. This asymmetry was not present for the audio-only group, where target words with the two vowels were fixated similarly. The results suggest that articulatory knowledge, acquired through both passive exposure to visual information (Experiment 1) and active production (Experiment 2), can help distinguishing words with difficult foreign sounds.

Chapter 5

General Discussion

5.1 Summary of Findings

In the studies leading to this cumulative dissertation, I investigated how the encoding of a difficult non-native sound contrast (/ɛ/-/æ/ for German learners of English) into L2 lexical representations relates to the phonetic abilities that learners display with the sounds involved in this contrast. This is a relevant question because, even though some parallels have been observed between L2 learners' performance in phonetic (i.e., sound level) and lexical (i.e., word level) tasks with difficult L2 distinctions (e.g., Nakai, Lindsay, & Ota, 2015; Silbert et al., 2015; Simonchyk & Darcy, 2017, 2018), findings suggest that phonetic abilities and lexical encoding need not always go hand in hand. An example of this are the many studies showing that, even when L2 learners get to a point in which their perceptual categorization of confusable L2 sounds is already comparable to that of native speakers, they still perform rather poorly in tasks focusing on the recognition of specific words containing these sounds (Broersma, 2005, 2012; Darcy et al., 2012; Sebastián-Gallés & Baus, 2005; Simon & Sjerps, 2017; Simon, Sjerps, & Fikkert, 2014). Hence, the main aim of this dissertation was to fill some gaps in the literature in order to reach a better understanding of how various components of what can be summed up as phonetic abilities concerning sounds in difficult L2 contrasts –mainly perceptual categorization, perceptual flexibility and articulation in production in the preceding chapters– may interact with the phonological encoding of these sounds onto lexical representations in the non-native language.

Chapter 2 was concerned with the imitation, that is, the perception and subsequent production, following a native model, of two contrasts differing in their degree of difficulty for German learners of English: the /ɛ/-/æ/ contrast, which tends to be extremely challenging, and the easier /i/-/ɪ/ contrast, shared by German and English. Crucially, the focus

was on how imitation patterns relate to performance in two other tasks probing each of imitation's two subcomponents in isolation: a phonetic categorization task examining perception and a word reading task assessing production. Relationships between the different tasks were tested using individual measures (therefore allowing for the capture of individual differences between participants) in order to answer two main research questions: i) to what extent does imitation relate to the state of the imitated categories (i.e., how strongly represented they are) in the learner's L2 phonological system? And ii) how tightly are imitation abilities related to how the same categories are productively used by learners when prompted to produce words in the non-native language? This chapter therefore intended to shed light on the perception-production link during L2 learning and, more in line with the main topic of this dissertation, it attempted to examine the potential impact of accessing L2 lexical representations on production abilities with challenging L2 distinctions.

Results showed that, as expected, learners were better at differentiating /i/-/ɪ/ than the difficult L2 contrast /ɛ/-/æ/ in both perception and production. In the perceptual categorization task, learners exhibited categorization functions that were steeper for the former than for the latter, while in the word reading task, the produced acoustic distances between /i/ and /ɪ/ were much larger than those between /ɛ/ and /æ/. Importantly, in the imitation task, where learners were asked to imitate the steps of the same two continua used in perceptual categorization, performance mirrored that of the previous tasks: the imitation functions, computed on binomially-transformed acoustic values for each continuum step, were steeper for /i/-/ɪ/ than for /ɛ/-/æ/ and the acoustic distance between the two endpoints of the continuum was greater for /i/-/ɪ/ than /ɛ/-/æ/ as well.

When individual performances with the difficult contrast were analyzed across tasks, two main findings emerged. The first one was that a correlation between individual performances in the perceptual categorization and the imitation task was found. This correlation indicates that production patterns in imitation are strongly related to how robust the perceptual distinction between the two categories is: the more clear-cut the distinction in perception, the more abrupt the changes in the acoustics of the imitated continuum steps. This is taken to suggest that the imitation of L2 sounds is constrained by how robustly these sounds are represented in the learner's phonological system and also to outline a tight perception-production link at the sound-category level for sounds in difficult L2 contrasts.

The second main finding was that a significant correlation between individual acoustic distances for /ɛ/-/æ/ in the imitation task (i.e., between continuum endpoints) and the word reading task could not be found. An examination of the data suggests that this is likely due to learners producing consistent acoustic differences between the two vowels in the imitation task but not in the word reading task, where /æ/ was very often produced with

values approximating [ɛ]. I argue that an explanation for this dissociation is that it is partly induced by lexical difficulties with words containing the critical vowels, since word reading is expected to entail the retrieval of the lexical representations of the words to be read. The production of /æ/ as [ɛ] is then thought to result from learners not having the L2 sound /æ/ robustly encoded to the lexical representations of the /æ/-words to be read aloud, which would prompt them to produce [ɛ] because of its dominant role in the contrast (see Cutler, Weber, & Otake, 2006; Hayes-Harb & Masuda, 2008). Results thus mirror, in the production domain, previous findings in perception where difficulties in lexical recognition have been documented in spite of accurate phonetic identification of difficult L2 contrasts (Amengual, 2016; Darcy, Daidone, & Kojima, 2013; Díaz, Mitterer, Broersma, & Sebastián-Gallés, 2012). Summarizing, Chapter 2 showed that imitation can provide valuable information about the sound-level representation of difficult L2 sounds and contrasts, but need not reflect the learners' productive lexical usage of these sounds.

In Chapter 3, it was investigated whether the robust lexical encoding of a difficult and an easy L2 contrast (same as in Chapter 2) into the word representations stored in the L2 lexicon is related to how flexible (or not) learners are with these contrasts in phonetic perception. This question was motivated by the fact that, while previous research confirmed that L2 learners are perceptually flexible (i.e., can move the perceptual boundary between sound categories) with non-native contrasts that are not problematic (Reinisch, Weber, & Mitterer, 2013; Schuhmann, 2014), there is some evidence that perceptual flexibility may not be desirable for challenging L2 sounds (Sjerps & McQueen, 2010). In Chapter 3, the lexical encoding of the /ɛ/-/æ/ and /i/-/ɪ/ English contrasts was assessed by means of a lexical decision task containing mispronunciations (e.g., *lemon* as *l[æ]mon and *dragon* as *dr[ɛ]gon, and the same for /i/-/ɪ/) and a distributional learning task on acoustic continua corresponding to the two contrasts was used to gauge into the learners' perceptual flexibility with these L2 distinctions. Individual performances in the two tasks were subsequently compared, separately for each contrast.

Results showed that, in the lexical decision task, learners were much less accurate at accepting real words and rejecting mispronounced nonwords with items corresponding to the challenging /ɛ/-/æ/ distinction than with items containing /i/ and /ɪ/. In addition, within the /ɛ/-/æ/ contrast, they were worse with words that had /æ/ and nonwords in which /æ/ was substituted by [ɛ] (e.g., *dr[ɛ]gon) than with /ɛ/ words and nonwords that had the opposite substitution pattern (e.g., *l[æ]mon). This agrees with previous research showing that Dutch and German learners of English have enhanced lexical difficulties with the new L2 sound /æ/ in comparison to /ɛ/, which is reasonably similar in their L1 and L2 (Broersma, 2005; Díaz et al., 2012; Eger & Reinisch, 2017, 2019; Simon et al., 2014). Regarding the distributional learning task, learners as a group were found to shift their phonetic category

boundaries between both /i/-/ɪ/ and /ɛ/-/æ/ in response to the biases introduced through exposure to frequency distributions of continuum steps. However, a relationship between lexical decision and distributional learning was only found for /ɛ/-/æ/. More precisely, the main finding of this chapter was that learners who performed better with /ɛ/ words and *l[æ]mon-type mispronunciations in lexical decision shifted their boundary between the two phonetic categories less during distributional learning.

I argue that the relationship between a better lexical encoding and rigidity at the phonetic category level in perception stems from the difficulties inherent in the acquisition of a contrast such as /ɛ/-/æ/ for German learners of English. While, from the results of this study, it is not possible to establish a clear-cut causal or consequential relationship between the two measures considered, two alternative explanations are put forward for the observed results. The first one is that the better learners, as reflected by performance in the lexical decision task, are less flexible with the /ɛ/-/æ/ because their rigidity responds to an attempt to keep their phonetic categories stable once they already find themselves being reasonably successful at dealing with the difficult L2 contrast. The second hypothesis is, on the contrary, that a more robust phonolexical encoding of /ɛ/ and /æ/ comes as a result of being less flexible with these categories at the phonetic level. Being excessively flexible or adaptable may result in uncertainty about the phonetic properties of the two sounds, compromising thus the accurate encoding of these categories into words in the L2. By contrast, maintaining a rigid boundary possibly has a facilitative effect by reducing uncertainty at the phonetic level. Crucially, the findings in this chapter suggest, in more general terms, that a lack of flexibility in perception may be advantageous for difficult L2 sound distinctions. This reinforces the idea put forward by Sjerps and McQueen (2010) that the same flexibility that has been shown to be beneficial in first-language listening (e.g., Bradlow & Bent, 2008; Norris, McQueen, & Cutler, 2003) may be costly when it comes to problematic non-native categories.

Finally, Chapter 4 also examined the encoding of the challenging English /ɛ/-/æ/ contrast into L2 lexical representations for German learners of English. However, instead of using real English words like in Chapter 3, a novel word learning paradigm was introduced so that the establishment of lexical representations in the L2 could be prompted for words (e.g., *tenzer-tandek*) with which participants had not had any experience before. In particular, it was investigated whether encoding /ɛ/ and /æ/ as two different categories in the novel words would be facilitated by learners being exposed to additional information about the articulatory properties of the critical sounds during word learning, similarly to how orthographic representations were found to be of help in a similar scenario (Escudero, Hayes-Harb, & Mitterer, 2008). Two different sources of articulatory information were considered: (i) passive exposure to the mouth and jaw movements of a native speaker,

presented via audiovisual stimuli, and (ii) one's own active articulation of the target words through delayed repetition of the critical stimuli. In two experiments, learners were trained to learn the novel English words while being provided with specific types of feedback to their responses and, afterwards, their online recognition of these words was probed by looking at their eye-gaze patterns in a visual world eye-tracking task. In Experiment 1, one group of learners was exposed to the words only in the audio modality during training (Audio condition), whereas learners in a second group saw videos of the speaker articulating the target words simultaneously with the auditory tokens as feedback to their responses (Video condition). In Experiment 2, learners were asked to repeat the target words themselves as part of their feedback (Repetition condition). The main question was whether the articulatory information obtained by learners would have an effect on how they represented the novel words in the L2 lexicon, and more specifically, whether this information would help encode a distinction between /ɛ/ and /æ/ in these representations. If learners had encoded the distinction or not was to be determined by whether they showed the asymmetry in eye-gaze fixations in favor of /ɛ/ words reported for real English words by previous studies (Escudero et al., 2008; Weber & Cutler, 2004).

In Experiment 1, it was found that only the learners who were exposed to visual information about the articulation of /ɛ/ and /æ/ throughout the training phase (i.e., Video condition) showed an asymmetric fixation pattern during word recognition in the test phase: /ɛ/ targets (e.g., *tenzer*) were fixated faster than /æ/ targets (e.g., *tandek*). Learners who were trained with audio-only stimuli (i.e., Audio condition) did not show this asymmetry. In Experiment 2, the aforementioned preference for /ɛ/ targets at test was replicated for the group of participants who were asked to repeat the target words after the native model during training. Hence, the main finding of this chapter was that the two groups of participants who obtained information about the articulation of the target sounds were able to encode a difference between the two vowels in the novel words they heard, while those who did not have access to additional articulatory information were not.

Importantly, the results of Experiment 1 provide evidence that the benefit that visual information has been repeatedly found to have on phonetic training and perceptual categorization of difficult L2 contrasts (e.g., Hazan et al., 2006; Hazan, Sennema, Iba, & Faulkner, 2005) extends to the encoding of these categories into L2 lexical representations. In Experiment 2, however, learners were not given any additional external information (e.g., visual) about how the words, and the sounds within, were produced. The only additional information to the auditory stimuli they obtained was their own articulation. Therefore, the ability to encode a difference between the two sounds in the novel words needs to be attributed to learners picking up on contrastive information from their own productions. A possible explanation for the similar effectiveness of the two types of articulatory information is that

both the presentation of videos and the active production of the target words were likely to help focus the learners' attention to the individual sounds composing the novel words. This would be in line with the findings in Escudero et al. (2008), since orthography could also have triggered a heightened attention to each of the individual sounds in the words via sound-to-orthography mapping. In sum, the two experiments in this chapter show that phonetic, production-related information during word learning is a useful cue to establish distinctions between non-native categories that are difficult to tease apart in novel L2 items. Thus it appears that boosting one's phonetic knowledge about the critical categories at the very moment that learning is taking place can result in a better encoding of these sounds into new L2 lexical representations.

5.2 Conclusions

Two main concluding remarks can be made about the interplay between phonetic abilities and the lexicon in second language learning based on the findings of the experimental work reported in Chapters 2, 3 and 4. The first of them can be seen as mildly discouraging for L2 learners and researchers alike, since it goes back to something that we have known for a long time: mastering a second language is never easy. In fact, it is always more challenging than expected. However, the second take-home message allows for more optimism in that it leads to envisaging new promising avenues of research on this topic.

The first conclusion is that there is indeed a large gap between L2 learners' performance with difficult L2 contrasts in tasks solely taping into phonetic abilities and tasks involving lexical access. While previous research has already pointed towards this disparity in L2 perception (e.g., Amengual, 2016; Darcy et al., 2013; Díaz et al., 2012; Simonchyk & Darcy, 2017), this thesis not only provides further evidence of its existence in perception (Chapter 3), but crucially, it also extends this finding to L2 production (Chapter 2). In the first place, Chapter 3 shows that German learners of English were extremely accurate (over 95% correct) when perceptually categorizing the endpoints of a *bet-bat* continuum in a distributional learning task, irrespective of the effects that distributional learning had on their responses. This indicates that, in a perception task that led them to focus on the phonetic detail of the vowel sound in the stimuli, they did not have difficulties in identifying a prototypical [ɛ] as /ɛ/ and a prototypical [æ] as /æ/. However, in a lexical decision task, they were unable to reliably reject nonwords constructed by replacing the critical vowel in the word by the other vowel in the contrast (e.g., *l[æ]mon, *dr[ɛ]gon). While it could still be argued that the much poorer performance in the lexical decision task was partly caused by its higher task demands or its enhanced difficulty (Bosker, Reinisch, & Sjerps,

2017; Mattys & Wiget, 2011) when compared to a simpler perceptual categorization task, note that learners were nonetheless quite accurate at rejecting nonwords when the mispronunciations concerned sounds that are part of both their L1 and L2 inventory (e.g., /i/ vs. /ɪ/, filler contrasts like /k/-/m/). Hence, it had to be the specific lexical difficulties they have with /ɛ/ and /æ/ that led to such generalized poor performances.

Most importantly, Chapter 2 showed a parallel asymmetry in speech production. It was found that learners were overall able to produce a reliable acoustic distinction between the L2 sounds /ɛ/ and /æ/ in a production task that lead them to focus on the phonetic detail of the critical vowel (i.e., imitation of *bet-bat* continuum steps), similarly to the perceptual categorization task in the paragraph above. By contrast, when learners were asked to read written words aloud, the acoustic distance between the two vowels diminished considerably, the contrast being effectively merged or near-merged by many learners. Critically, contrary to Chapter 3, the lexically-oriented word reading task was this time the less-demanding task of the two. Hence, the results of Chapter 2 serve to illustrate that, also in L2 production, a domain in which the relationship between performance at the phonetic and lexical levels remains comparatively understudied, lexical shortcomings appear to trigger difficulties that are of a greater magnitude than those that learners actually have to produce the L2 sounds correctly. Additionally, in this chapter, individual measures were used to calculate acoustic distances in the two tasks so that it could be assessed whether a clearer separation between the two vowels in one task related to a clearer separation in the other task at the individual level. Unlike in perception, where it has been found that accuracy in distinguishing difficult L2 sounds relates to how reliably these sounds are encoded in lexical entries (Silbert et al., 2015; Simonchyk & Darcy, 2017), a significant correlation between vowel production in the phonetically-oriented imitation task and the lexical word reading task could not be found.

In sum, findings from Chapters 2 and 3 suggest that the enhanced difficulties learners experienced with /ɛ/ and /æ/ in the tasks tapping into the L2 lexicon stem from the weak encoding of the sounds in that contrast to their existing lexical representations, and not simply from confusion at the phonetic level, for learners were shown to be well able to identify the sounds in perception and produce them quite accurately when lexical access was not central to the task at hand. Note that these are not good news for L2 learners, since the vast majority of the everyday situations in which the L2 is used involves recognizing and producing words. A potential explanation for the heightened lexical difficulties is that, as a native German speaker, reaching a strong lexical encoding of L2 sounds like /ɛ/ and /æ/ requires, in addition to being able to establish two separate sound categories for these vowels, that one is extensively exposed to the words containing these sounds so as to obtain enough evidence of which sound is in place in each case. The reason for this is that, when learning L2 words and incorporating them to the lexicon, learners need to establish

word-sized representations and may therefore not give much attention to each particular segment (see Pajak, Creel, & Levy, 2016). Hence, L2 categories that are more effortful to differentiate from one another (like /ɛ/ and /æ/), even if possibly distinguishable in phonetic perception and production, may not get robustly encoded in lexical representations until learners obtain strong evidence of the identity of the critical vowel in each word. This explanation is in line with the findings of Escudero et al. (2008) and Chapter 4 in this thesis, where German speakers learned novel English words with /ɛ/ and /æ/. Only when learners were either given additional information about the critical vowels (i.e., orthography or articulatory movements) or were prompted to focus on the individual sounds by the task (i.e., by asking them to repeat the words) did they establish a distinction between /ɛ/ and /æ/ in the novel words they heard. By contrast, if they learned the words only by listening to them, they treated /ɛ/ and /æ/ as the same sound. For these learners, the audio-only input they received during the experiment was not enough to reach lexical separation.

Fortunately, the second main conclusion of this dissertation is that the research outlined in the preceding chapters made substantial progress in identifying elements that play a relevant role in the encoding of challenging non-native sounds in the lexicon. A case in point is that Chapter 3 shows that, for existing L2 lexical representations, the robust phonological encoding of difficult non-native sounds is not only related to perceptual categorization or discrimination abilities with these sounds (see Silbert et al., 2015; Simonchyk & Darcy, 2017) but also to perceptual rigidity. Learners who were better able to reject mispronunciations like *l[æ]mon and *ch[æ]rry in a lexical decision task, showing thus a greater certainty about which the first vowel of these words was (i.e., better lexical encoding), shifted their perceptual boundary between /ɛ/ and /æ/ less in a distributional learning task designed to bias the learners' perception and trigger boundary shifts. This finding leads to the conclusion that the relationship between phonetic abilities and lexical encoding cannot be characterized as a simple link between perceptual identification (is this sound /ɛ/ or /æ/?) and lexical identification (does word X have /ɛ/ or /æ/?). Instead, it seems to be multifaceted in that various phonetic-level abilities modulate the learner's success in achieving lexical separation for these L2 distinctions. Whether there are other phonetic abilities (and, if so, which) contributing to determining the accuracy of lexical encoding of difficult L2 sounds is now a question for future research.

Unlike Chapter 3, Chapter 4 was not concerned with already existing L2 lexical representations but instead assessed the establishment of novel lexical representations containing a priori difficult L2 sounds. Crucially, together with previous results (Escudero et al., 2008), the results of Chapter 4 suggest that novel lexical representations are quite malleable with regard to the phonological encoding of difficult L2 sounds. Specifically, as already hinted above, it appears that obtaining information related to the identity of the sound in

each of the words during novel word learning results in a better, although still non-native, differentiation of the sounds in the difficult contrast. As argued in Chapter 4, this may be due to the fact that obtaining additional information makes learners more attentive to the individual segments making up the novel items. This would in turn help them be more certain about which of the L2 categories is present in each of the words learned. This line of research therefore points at the possibility that the heightened lexical difficulties with confusable L2 contrasts that learners experience (in comparison to their frequent relative success in phonetic processing) may be reduced if learners are prompted to allocate more attention, and thus possibly more cognitive resources, to identifying the critical sounds during word learning. Further research would be needed to test this hypothesis and, optimally, to extend its assessment to more naturalistic environments than the laboratory, such as for instance, the L2 classroom.

Finally, with regard to L2 learning in a broader, more general sense, a recurrent finding in this dissertation (Chapters 2 and 3) is that the learners' performance in tasks involving accessing L2 lexical representations relates quite tightly to their self-reported proficiency and experience with the non-native language. In Chapter 3, a combined measure of self-reported English proficiency and use calculated following Eger and Reinisch (2017) was found to correlate with accuracy in lexical decision for words containing /ɛ/ and nonwords in which /ɛ/ had been substituted by [æ] (e.g., *l[æ]mon); the better the self-reported score, the more accurate learners were. In Chapter 2, the same proficiency/use scores correlated with how distant in the acoustic space /ɛ/ and /æ/ were produced in a word reading task, which involved the retrieval of L2 lexical entries containing these two vowels. The more proficient and more accustomed to using English learners were, the larger their acoustic distance between the vowels in production. Most importantly, proficiency/use scores failed to correlate with acoustic distances between /ɛ/ and /æ/ in an imitation task with scarce lexical involvement. While sheer sound-level perception and production abilities with difficult L2 contrasts continue to be the main focus of a substantial part of the research conducted in the phonetic-phonological domain of L2 acquisition (e.g., Sadakata & McQueen, 2013; Thorin, Sadakata, Desain, & McQueen, 2018), these findings suggest that L2 proficiency and experience are more closely linked to and reflected by performance with difficult L2 contrasts in situations that are dependent on both phonetic and lexical mastery. In my view, this serves to highlight the importance of investigating the encoding of the sounds in such contrasts in the lexicon further because it appears to be the learners' ability to use them productively in situations involving words (i.e., almost any imaginable spoken exchange) —and not simply in explicit phonetic tasks— that matches best with their linguistic history and their overall command of the second language in question.

References

Amengual, M. (2016). The perception of language-specific phonetic categories does not guarantee accurate phonological representations in the lexicon of early bilinguals. *Applied Psycholinguistics*, *37*(5), 1221–1251. https://doi.org/10.1017/S0142716415000557

Bosker, H. R., Reinisch, E., & Sjerps, M. J. (2017). Cognitive load makes speech sound fast, but does not modulate acoustic context effects. *Journal of Memory and Language*, *94*, 166 - 176. https://doi.org/10.1016/j.jml.2016.12.002

Bradlow, A. R., & Bent, T. (2008). Perceptual adaptation to non-native speech. *Cognition*, *106*(2), 707–729. https://doi.org/10.1016/j.cognition.2007.04.005

Broersma, M. (2005). *Phonetic and lexical processing in a second language* (PhD thesis). Nijmegen, The Netherlands: Radboud University.

Broersma, M. (2012). Increased lexical activation and reduced competition in second-language listening. *Language and Cognitive Processes*, *27*(7-8), 1205–1224. https://doi.org/10.1080/01690965.2012.660170

Cutler, A., Weber, A., & Otake, T. (2006). Asymmetric mapping from phonetic to lexical representations in second-language listening. *Journal of Phonetics*, *34*(2), 269–284. https://doi.org/10.1016/j.wocn.2005.06.002

Darcy, I., Daidone, D., & Kojima, C. (2013). Asymmetric lexical access and fuzzy lexical representations in second language learners. *The Mental Lexicon*, *8*(3), 372–420. https://doi.org/10.1075/ml.8.3.06dar

Darcy, I., Dekydtspotter, L., Sprouse, R. A., Glover, J., Kaden, C., McGuire, M., & Scott, J. H. (2012). Direct mapping of acoustics to phonology: On the lexical encoding of front rounded vowels in L1 English–L2 French acquisition. *Second Language Research*, *28*(1), 5–40. https://doi.org/10.1177/0267658311423455

Díaz, B., Mitterer, H., Broersma, M., & Sebastián-Gallés, N. (2012). Individual differences in late bilinguals' L2 phonological processes: From acoustic-phonetic analysis to lexical access. *Learning and Individual Differences*, *22*(6), 680–689. https://doi.org/10.1016/j.lindif.2012.05.005

Eger, N. A., & Reinisch, E. (2017). The role of acoustic cues and listener proficiency in the

perception of accent in non-native sounds. *Studies in Second Language Acquisition*, 1–22. https://doi.org/10.1017/s0272263117000377

Eger, N. A., & Reinisch, E. (2019). The impact of one's own voice and production skills on word recognition in a second language. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(3), 552–571. https://doi.org/10.1037/xlm0000599

Escudero, P., Hayes-Harb, R., & Mitterer, H. (2008). Novel second-language words and asymmetric lexical access. *Journal of Phonetics*, *36*(2), 345–360. https://doi.org/10.1016/j.wocn.2007.11.002

Hayes-Harb, R., & Masuda, K. (2008). Development of the ability to lexically encode novel second language phonemic contrasts. *Second Language Research*, *24*, 5–33. https://doi.org/10.1177/0267658307082980

Hazan, V., Sennema, A., Faulkner, A., Ortega-Llebaria, M., Iba, M., & Chunge, H. (2006). The use of visual cues in the perception of non-native consonant contrasts. *The Journal of the Acoustical Society of America*, *119*(3), 1740–1751. https://doi.org/10.1121/1.2166611

Hazan, V., Sennema, A., Iba, M., & Faulkner, A. (2005). Effect of audiovisual perceptual training on the perception and production of consonants by Japanese learners of English. *Speech Communication*, *47*(3), 360–378. https://doi.org/10.1016/j.specom.2005.04.007

Mattys, S. L., & Wiget, L. (2011). Effects of cognitive load on speech recognition. *Journal of Memory and Language*, *65*(2), 145–160. https://doi.org/10.1016/j.jml.2011.04.004

Nakai, S., Lindsay, S., & Ota, M. (2015). A prerequisite to L1 homophone effects in L2 spoken-word recognition. *Second Language Research*, *31*(1), 29–52. https://doi.org/10.1177/0267658314534661

Norris, D., McQueen, J. M., & Cutler, A. (2003). Perceptual learning in speech. *Cognitive Psychology*, *47*(2), 204–238. https://doi.org/10.1016/S0010-0285(03)00006-9

Pajak, B., Creel, S. C., & Levy, R. (2016). Difficulty in learning similar-sounding words: A developmental stage or a general property of learning? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*(9), 1377–1399. https://doi.org/10.1037/xlm0000247

Reinisch, E., Weber, A., & Mitterer, H. (2013). Listeners retune phoneme categories across languages. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(1), 75–86. https://doi.org/10.1037/a0027979

Sadakata, M., & McQueen, J. M. (2013). High stimulus variability in nonnative speech learning supports formation of abstract categories: Evidence from Japanese geminates. *The Journal of the Acoustical Society of America*, *134*(2), 1324–1335. https://doi.org/10.1121/1.4812767

Schuhmann, K. S. (2014). *Perceptual learning in second language learners* (PhD thesis). State University of New York at Stony Brook.

Sebastián-Gallés, N., & Baus, C. (2005). On the relationship between perception and production in L2 categories. In A. Cutler (Ed.), *Twenty-first century psycholinguistics: Four cornerstones* (pp. 279–292). Hillsdale, NJ: LEA.

Silbert, N. H., Smith, B. K., Jackson, S. R., Campbell, S. G., Hughes, M. M., & Tare, M. (2015). Non-native phonemic discrimination, phonological short term memory, and word learning. *Journal of Phonetics*, *50*, 99–119. https://doi.org/10.1016/J.WOCN.2015.03.001

Simon, E., & Sjerps, M. J. (2017). Phonological category quality in the mental lexicon of child and adult learners. *International Journal of Bilingualism*, *21*(4), 474–499. https://doi.org/10.1177/1367006915626589

Simon, E., Sjerps, M. J., & Fikkert, P. (2014). Phonological representations in children's native and non-native lexicon. *Bilingualism: Language and Cognition*, *17*(1), 3–21. https://doi.org/10.1017/S1366728912000764

Simonchyk, A., & Darcy, I. (2017). Lexical encoding and perception of palatalized consonants in L2 Russian. In *Proceedings of the 8th Pronunciation in Second Language Learning and Teaching Conference, INSS* (pp. 2380–9566).

Simonchyk, A., & Darcy, I. (2018). The effect of orthography on the lexical encoding of palatalized consonants in L2 Russian. *Language and Speech*, *61*(4), 522–546. https://doi.org/10.1177/0023830918761490

Sjerps, M. J., & McQueen, J. M. (2010). The bounds on flexibility in speech perception. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(1), 195–211. https://doi.org/10.1037/a0016803

Thorin, J., Sadakata, M., Desain, P., & McQueen, J. M. (2018). Perception and production in interaction during non-native speech category learning. *The Journal of the Acoustical Society of America*, *144*(1), 92-103. https://doi.org/10.1121/1.5044415

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language*, *50*(1), 1–25. https://doi.org/10.1016/S0749-596X(03)00105-0

Appendix A

List of Publications

Llompart, M. & Reinisch, E. (2018). Imitation in a second language relies on phonological categories but does not reflect the productive usage of difficult sound contrasts. *Language and Speech.* https://doi.org/10.1177/0023830918803978

Llompart, M. & Reinisch, E. (2018). Robustness of phonolexical representations relates to phonetic flexibility for difficult second language sound contrasts. *Bilingualism: Language and Cognition*, 1–16. https://doi.org/10.1017/S1366728918000925

Llompart, M. & Reinisch, E. (2018). Acoustic cues, not phonological features, drive vowel perception: Evidence from height, position and tenseness contrasts in German vowels. *Journal of Phonetics, 67*, 34–48. https://doi.org/10.1016/j.wocn.2017.12.001

Llompart, M. & Simonet, M. (2018). Unstressed vowel reduction across Majorcan Catalan dialects: Production and spoken word recognition. *Language & Speech, 61*(3), 430–465. https://doi.org/10.1177/0023830917736019

Llompart, M. & Reinisch, E. (2017). Articulatory information helps encode lexical contrasts in a second language. *Journal of Experimental Psychology: Human Perception and Performance, 43*(5), 1040–1056. https://doi.org/10.1037/xhp0000383

Nadeu, M., Simonet M. & **Llompart M.** (2017). Stressed postverbal pronominals in Catalan. *Probus: International Journal of Latin and Romance Linguistics, 29*(1), 119–162. https://doi.org/10.1515/probus-2016-0016

Llompart, M. & Casillas, J. V. (2016). Lexically-driven selective adaptation by ambiguous auditory stimuli occurs after limited exposure to adaptors. *Journal of the Acoustical Society of America, 139*(5), EL172–EL177. https://doi.org/10.1121/1.4951704

Llompart, M. (2016). Subject-verb order variation with unaccusative verbs of change of location in Mexico and Southern Arizona. *Studies in Hispanic and Lusophone Linguistics, 9*(1), 143–173. https://doi.org/10.1515/shll-2016-0006

Llompart, M., Simonet M. (2015). Differential positional neutralization of back vowels in two Majorcan Catalan subdialects. In The Scottish Consortium for ICPhS (Eds.), *Proceedings of the 18th International Congress of Phonetic Sciences* (paper 781). Glasgow, Scotland.

Llompart, M. (2013). La "r francesa" en Sóller (Mallorca) y su relación con la adquisición de L1 y L2 en hablantes bilingües catalanodominantes. *Estudios de Fonética Experimental*, 22, 193–232. http://stel.ub.edu/labfon/sites/default/files/XXII-10-MLlompart.pdf

Appendix B

List of Author Contributions

Chapter 2

Llompart, M. & Reinisch, E. (2018). Imitation in a second language relies on phonological categories but does not reflect the productive usage of difficult sound contrasts. Language and Speech. https://doi.org/10.1177/0023830918803978

The author of this dissertation is the first author of this manuscript and was primarily involved in situating the research questions within the existing literature, designing and programing the experiment, collecting and analyzing the data, interpreting the results and writing the manuscript. Eva Reinisch supervised the project. She provided advice on situating the project in the literature, contributed to experimental design, data analysis and interpretation of the results, and commented on and helped revise the manuscript.

Chapter 3

Llompart, M. & Reinisch, E. (2018). Robustness of phonolexical representations relates to phonetic flexibility for difficult second language sound contrasts. Bilingualism: Language and Cognition, 1–16. https://doi.org/10.1017/S1366728918000925

The author of this dissertation is the first author of this manuscript and was primarily involved in literature review, experimental design, data collection and analysis, interpretation of the results and manuscript writing. Eva Reinisch supervised the project, contributed to the experimental design, as well as to the analysis and interpretation of the results, and commented on and helped revise the manuscript.

Chapter 4

Llompart, M. & Reinisch, E. (2017). Articulatory information helps encode lexical contrasts in a second language. Journal of Experimental Psychology: Human Perception and Performance, 43(5), 1040–1056. https://doi.org/10.1037/xhp0000383

The author of this dissertation is the first author of this manuscript and was the primary contributor to literature review, experimental design, data collection and analysis, interpretation of the results and writing the manuscript. Eva Reinisch supervised the project. She contributed to experimental design, experimental programming and data analysis. She also advised on the theoretical framing of the study and commented on and helped revise the manuscript.

Zusammenfassung

Beim Erwerb einer Fremdsprache, wenn die Erstsprache bereits beherrscht wird, kann es extrem schwierig sein, bestimmte Laute zu erlernen. Vor allem jene Fälle sind problematisch, in denen zwei in der Fremdsprache (L2) kontrastive Lautkategorien in akustischer/perzeptiver Hinsicht nah an einer einzelnen Lautkategorie der Erstsprache (L1) liegen (siehe Best & Tyler, 2007). Ein Beispiel hierfür ist der Kontrast /ɛ/-/æ/ im Englischen für Muttersprachler*innen des Deutschen (z.B. Eger & Reinisch, 2019), da beide englischen Laute dem deutschen Vokal /ɛ/ ähnlich sind, wobei das englische /ɛ/ besser zu der deutschen Kategorie passt als der englische Vokal /æ/. Die Notwendigkeit, zwischen diesen fremdsprachlichen Lautkontrasten wie /ɛ/-/æ/ zu unterscheiden, bereitet Schwierigkeiten auf zwei miteinander verwobenen Ebenen in der Verarbeitung und Repräsentation von Lauten: zunächst einmal ist die Unterscheidung auf der Ebene der Laute oder phonetischen Kategorien problematisch. Das bedeutet, dass Lerner*innen Schwierigkeiten haben, den akustischen Unterschied zwischen solchen Lauten korrekt wahrzunehmen und zu produzieren. Zweitens wirken sich diese Schwierigkeiten deutlich darauf aus, wie Lerner*innen Wörter mit solchen Lauten verarbeiten und wie diese Wörter im mentalen Lexikon repräsentiert sind, das heißt, wie Lerner*innen derartige Laute auf lexikalischer (d.h. Wort-)Ebene verwenden.

Damit deutsche Muttersprachler*innen, die Englisch lernen, einen Kontrast wie /ɛ/-/æ/ vollständig beherrschen, müssen zwei grundlegende Kriterien erfüllt werden. Erstens müssen sich die *phonetischen Fähigkeiten* der Lerner*innen so weit verbessern, dass sie fähig sind, eine spezifische Lautkategorie als solche wahrzunehmen und zu produzieren, und eben nicht als den anderen Laut des Kontrastes (z.B. /æ/ als [æ] und nicht als [ɛ]; Bohn & Flege, 1990, 1992; Flege, Bohn, & Jang, 1997). Zweitens müssen die Lautkategorien korrekt jenen L2-Wörtern zugewiesen werden, zu denen sie tatsächlich gehören (Broersma, 2005; Weber & Cutler, 2004). Das heißt, sie müssen korrekt als einer der phonologischen Bestandteile enkodiert werden, welche die lexikalische Repräsentation bestimmter L2-Wörter ausmachen (z.B. /æ/ sollte in der Repräsentation von *dragon* „Drache“ enthalten sein, aber nicht in der von *lemon* „Zitrone“). Auf genau dieses Prinzip wird verwiesen, wenn in der

vorliegenden Arbeit von lexikalischer Enkodierung (*lexical encoding*) die Rede ist. Genauer gesagt war es das Hauptziel dieser Arbeit, den Zusammenhang zwischen diesen beiden Anforderungen (phonetische Fähigkeiten und lexikalische Enkodierung) zu untersuchen. Mithilfe verschiedener experimenteller Methoden wurden in den Kapiteln 2, 3 und 4 einige Schlüsselfragen adressiert. Diese betrafen den Zusammenhang zwischen dem Erstellen gut definierter phonetischer Kategorien für die englischen Laute /ɛ/ und /æ/ einerseits, sowie die korrekte und konsistente Verknüpfung solcher Lautkategorien zu einzelnen lexikalischen Einträgen englischer Wörter für deutsche Lerner*innen andererseits.

Kapitel 2 beschäftigte sich mit der Frage, wie deutsche Muttersprachler*innen Lautkontraste des Englischen als L2 imitieren, das heißt, wie sie von einem englischen Sprecher produzierte L2-Laute wahrnehmen und diese selbst produzieren (z.B. Flege & Eefting, 1988; Hao & de Jong, 2016). Der Fokus lag auf dem Vergleich zwischen Imitationsmustern (Nachsprech-/Imitationsaufgabe), der Fähigkeit, diese Laute perzeptiv zu identifizieren (Kategorisierungsaufgabe) und der Produktion derselben Laute in L2-Wörtern (Vorleseaufgabe mit einzelnen Wörtern). Dabei wurden der schwierige L2-Kontrast /ɛ/-/æ/ und ein Kontrast, der auch im Deutschen existiert (/i/-/ɪ/), untersucht. Analysen der Unterschiede zwischen den zwei Kontrasten einerseits und Zusammenhänge zwischen den verschiedenen Aufgaben innerhalb der Kontraste andererseits ergaben einige relevante Erkenntnisse. Erstens stellte sich der L2-Kontrast /ɛ/-/æ/ in allen Aufgabentypen als schwieriger heraus als der Kontrast /i/-/ɪ/, wie zu erwarten war. Zweitens, die Fähigkeit, den schwierigen L2-Kontrast zu imitieren, hing eng mit den perzeptiven Kategorisierungsmustern innerhalb der Lerner*innen zusammen. Drittens, der Unterschied, den Lerner*innen zwischen /ɛ/ und /æ/ in der Imitationsaufgabe produzierten, hing nicht damit zusammen, wie gut sie diese Laute in der Vorleseaufgabe (in Wörtern) differenzierten. Diese Ergebnisse zeigten, dass Lerner*innen die L2-Laute in einer Imitationsaufgabe, welche die Aufmerksamkeit auf die phonetischen Eigenschaften der Vokale lenkt, differenzieren können. In der Vorleseaufgabe hingegen produzierten sie /æ/ sehr häufig mit akustischen Werten, die nah an [ɛ] lagen. Eine wahrscheinliche Erklärung dafür ist, dass Lerner*innen /æ/ auf Anforderung korrekt produzieren können, für diesen Laut aber noch keine robuste phonologische Kategorie in /æ/-Wörtern ausgebildet haben, wenn sie diese vorlesen. Diese Resultate aus dem Bereich der Produktion spiegeln vorherige Erkenntnisse aus dem Bereich der Perzeption wieder, welche zeigten, dass Lerner*innen Schwierigkeiten bei der Erkennung von Wörtern mit schwierigen L2-Lauten hatten, obwohl dieselben Laute korrekt identifiziert wurden (Amengual, 2016; Darcy, Daidone, & Kojima, 2013; Díaz, Mitterer, Broersma, & Sebastián-Gallés, 2012).

Kapitel 3 untersuchte die Frage, ob eine robuste Enkodierung von Lauten aus L2-Kontrasten in den Wortrepräsentationen im L2-Lexikon damit zusammenhängt, wie flexibel

(oder nicht) Lerner*innen mit diesen Kontrasten hinsichtlich phonetischer Wahrnehmung sind. Um dies zu testen, wurden dieselben Vokalkontraste des Englischen wie in Kapitel 2 verwendet. Die lexikalische Enkodierung der englischen Kontraste /ɛ/-/æ/ and /i/-/ɪ/ wurde anhand eines lexikalischen Entscheidungstests mit Stimuli bestimmt, in denen die kritischen Laute falsch ausgesprochen wurden (z.B. *lemon* „Zitrone“ als *l[æ]mon, und *dragon* „Drache“ als *dre[ɛ]gon, sowie in gleicher Weise für /i/-/ɪ/). Um die Flexibilität in der Perzeption zu quantifizieren, wurde eine *Distributional-Learning*-Aufgabe (ein Paradigma aus dem Bereich des Statistischen Lernens; siehe Clayards, Tanenhaus, Aslin, & Jacobs, 2008) mit akustischen Kontinua der beiden Kontraste verwendet. Die Ergebnisse der Individuen aus diesen beiden Tests wurden dann, für jeden der Kontraste separat, miteinander verglichen. Die Haupterkenntnis war, dass nur für den schwierigen Kontrast /ɛ/-/æ/ ein Zusammenhang gefunden wurde. Genauer gesagt, Lerner*innen, die im lexikalischen Entscheidungstest besser darin waren, reale Wörter des Englischen mit /ɛ/ zu akzeptieren und falsche Produktionen vom Typ *l[æ]mon abzulehnen, verschoben ihre perzeptive Grenze zwischen den zwei phonetischen Kategorien im *Distributional-Learning*-Test weniger. Es wurden zwei Hypothesen aufgestellt, um diesen Zusammenhang zwischen robuster lexikalischer Enkodierung und Rigidität in der Perzeption zu erklären. Auf der einen Seite könnte Rigidität in der Perzeption Lerner*innen als Mittel dienen, phonetische Kategorien zu festigen, wenn sie es geschafft haben, die Laute zuverlässig zu unterscheiden. Auf der anderen Seite ist die bevorzugte Erklärung, dass Stabilität in der Perzeption eine direktere Enkodierung phonetisch-phonologischer Information in lexikalischen Repräsentationen ermöglicht, indem Unsicherheit auf der phonetischen Ebene reduziert wird. Der Hauptbeitrag dieses Kapitels ist es, eine neue perzeptive Fähigkeit (perzeptive Flexibilität) zu identifizieren, die bei der Betrachtung von Faktoren, welche die lexikalische Enkodierung betreffen, berücksichtigt werden muss. Darüber hinaus bekräftigen diese Resultate die Idee von Sjerps and McQueen (2010), dass dieselbe perzeptive Flexibilität, die sich als vorteilhaft für die Wahrnehmung in der Erstsprache gezeigt hat (z.B. Bradlow & Bent, 2008; Norris, McQueen, & Cutler, 2003), nachteilhaft sein kann, wenn es um problematische fremdsprachliche Kategorien geht.

Auch Kapitel 4 untersuchte die Enkodierung des englischen Kontrastes /ɛ/-/æ/ in L2 lexikalischen Repräsentationen bei Englischlerner*innen mit Deutsch als L1. Anstatt reale englische Wörter wie in Kapitel 3 zu betrachten, wurde diesmal ein Trainingsparadigma verwendet, in welchem neue Wörter erlernt werden, um das Erstellen neuer L2 lexikalischer Repräsentationen mit den kritischen Lauten zu testen (z.B. *tenzer-tandek*). Hierbei wurde getestet, ob die lexikalische Enkodierung von /ɛ/ und /æ/ als zwei unterschiedliche Kategorien in neuen Wörtern dadurch erleichtert wird, dass Lerner*innen Zugang zu zusätzlichen Informationen über die artikulatorischen Eigenschaften dieser Laute in

der Trainingsphase haben. Diese könnten auf eine ähnliche Art und Weise genutzt werden wie orthographische Darstellungen, die in einem vergleichbaren Szenario nachweislich nützlich waren (Escudero, Hayes-Harb, & Mitterer, 2008). Zusätzlich zu einer Vergleichsgruppe, welche die Wörter nur durch Zuhören lernte (Audio-Bedingung), erhielten zwei andere vergleichbare Lerner-Gruppen während des Trainings zusätzliche artikulatorische Information aus einer von zwei unterschiedlichen Quellen: einer Gruppe (Experiment 1) wurden passiv audiovisuelle Stimuli präsentiert, die Mund- und Kieferbewegungen eines Muttersprachlers bei der Produktion der zu erlernenden Wörter zeigten (Video-Bedingung). Die andere Lerner-Gruppe (Experiment 2) sollte aktiv die Zielwörter artikulieren, die sie aufgrund der Vorgabe des Muttersprachlers zu wiederholen hatten (Wiederholungs-Bedingung). Nach dem Training wurde in einem Eye-tracking-Test geprüft (siehe Weber & Cutler, 2004), wie sie die Wörter in Echtzeit erkennen. Analysen der Blickmuster der Lerner*innen zeigten, dass sowohl die Lerner*innen in der Video- als auch jene in der Wiederholungs-Bedingung /ɛ/ und /æ/ erfolgreich als zwei unterschiedliche Kategorien in den neu erstellten lexikalischen Repräsentationen der neuen Wörter enkodiert hatten. Dies wurde durch die verschiedenen Fixationsmuster zu den Wörtern mit den zwei Vokalen belegt. Für Lerner*innen in der Audio-Bedingung hingegen verhielten sich die zwei Laute ähnlich in der Worterkennung, was stark darauf hindeutet, dass /ɛ/ und /æ/ in den lexikalischen Repräsentationen nicht unterschieden wurden. Dieses Kapitel zeigt, dass sich Information über die Artikulation von Lauten bei dem Erwerb neuer Wörter positiv darauf auswirken kann, wie robust die Laute eines schwierigen L2-Kontrastes in neuen L2 lexikalischen Einträgen enkodiert werden.

Zwei Hauptschlussfolgerungen können aus den Arbeiten dieser Dissertation gezogen werden. Erstens erbringen Kapitel 2 und 3 einen Nachweis dafür, dass es tatsächlich eine große Lücke gibt zwischen den Fähigkeiten der Lerner*innen in phonetischen Aufgaben mit schwierigen L2-Kontrasten (wie /ɛ/-/æ/) einerseits und andererseits solchen Aufgaben, bei denen auf lexikalische Repräsentationen zugegriffen wird. Während frühere Forschung bereits auf diese Diskrepanz im Bereich der L2-Wahrnehmung und Worterkennung hingewiesen hat (z.B. Díaz et al., 2012), trägt diese Arbeit nicht nur zu den Erkenntnissen früherer Arbeiten bei (Kapitel 3), sondern erweitert diese auch wesentlich auf den Bereich der Produktion von L2-Lauten und -Wörtern (Kapitel 2). Zweitens, und besonders wichtig, zeigen Kapitel 3 und 4, dass die lexikalische Enkodierung von Lauten in schwierigen L2-Kontrasten ein komplexer und facettenreicher Prozess ist, welcher sichtlich von phonetischen Fähigkeiten moduliert wird, die nicht auf die bloße perzeptive Kategorisierung beschränkt sind (Kapitel 3), als auch von den Informationen, die den Lerner*innen im Augenblick des Worterwerbs zur Verfügung stehen (Kapitel 4).

Literaturverzeichnis

Amengual, M. (2016). The perception of language-specific phonetic categories does not guarantee accurate phonological representations in the lexicon of early bilinguals. *Applied Psycholinguistics*, *37*(5), 1221–1251. https://doi.org/10.1017/S0142716415000557

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In O. S. Bohn & M. J. Munro (Eds.), *Language experience in second language speech learning: In honor of James Emil Flege* (pp. 13–34). Amsterdam, the Netherlands: John Benjamins. https://doi.org/10.1075/lllt.17.07bes

Bohn, O.-S., & Flege, J. E. (1990). Interlingual identification and the role of foreign language experience in L2 vowel perception. *Applied Psycholinguistics*, *11*(3), 303–328. https://doi.org/10.1017/S0142716400008912

Bohn, O.-S., & Flege, J. E. (1992). The production of new and similar vowels by adult German learners of English. *Studies in Second Language Acquisition*, *14*(2), 131–158. https://doi.org/10.1017/S0272263100010792

Bradlow, A. R., & Bent, T. (2008). Perceptual adaptation to non-native speech. *Cognition*, *106*(2), 707–729. https://doi.org/10.1016/j.cognition.2007.04.005

Broersma, M. (2005). *Phonetic and lexical processing in a second language* (PhD thesis). Nijmegen, The Netherlands: Radboud University.

Clayards, M., Tanenhaus, M. K., Aslin, R. N., & Jacobs, R. A. (2008). Perception of speech reflects optimal use of probabilistic speech cues. *Cognition*, *108*(3), 804–809. https://doi.org/10.1016/j.cognition.2008.04.004

Darcy, I., Daidone, D., & Kojima, C. (2013). Asymmetric lexical access and fuzzy lexical representations in second language learners. *The Mental Lexicon*, *8*(3), 372–420. https://doi.org/10.1075/ml.8.3.06dar

Díaz, B., Mitterer, H., Broersma, M., & Sebastián-Gallés, N. (2012). Individual differences in late bilinguals' L2 phonological processes: From acoustic-phonetic analysis to lexical access. *Learning and Individual Differences*, *22*(6), 680–689. https://doi.org/10.1016/j.lindif.2012.05.005

Eger, N. A., & Reinisch, E. (2019). The impact of one's own voice and production skills on word recognition in a second language. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(3), 552–571. https://doi.org/10.1037/xlm0000599

Escudero, P., Hayes-Harb, R., & Mitterer, H. (2008). Novel second-language words and asymmetric lexical access. *Journal of Phonetics*, *36*(2), 345–360. https://doi.org/10.1016/j.wocn.2007.11.002

Flege, J. E., Bohn, O.-S., & Jang, S. (1997). Effects of experience on non-native speakers' production and perception of English vowels. *Journal of Phonetics*, *25*(4), 437–470. https://doi.org/10.1006/jpho.1997.0052

Flege, J. E., & Eefting, W. (1988). Imitation of a VOT continuum by native speakers of English and Spanish: Evidence for phonetic category formation. *The Journal of the Acoustical Society of America*, *83*(2), 729-740. https://doi.org/10.1121/1.396115

Hao, Y.-C., & de Jong, K. (2016). Imitation of second language sounds in relation to L2 perception and production. *Journal of Phonetics*, *54*, 151–168. https://doi.org/10.1016/j.wocn.2015.10.003

Norris, D., McQueen, J. M., & Cutler, A. (2003). Perceptual learning in speech. *Cognitive Psychology*, *47*(2), 204–238. https://doi.org/10.1016/S0010-0285(03)00006-9

Sjerps, M. J., & McQueen, J. M. (2010). The bounds on flexibility in speech perception. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(1), 195–211. https://doi.org/10.1037/a0016803

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken-word recognition. *Journal of Memory and Language*, *50*(1), 1–25. https://doi.org/10.1016/S0749-596X(03)00105-0