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M.A. Thesis

Phonological Representations in the Mental Lexicon of Second Language Learners: A Synthesis

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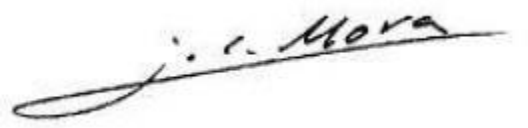

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Abstract

Being able to perceive the difference between two sounds can be difficult for L2 learners. This synthesis aims at analyzing the processes that occur during the encoding of phonological representations into the mental lexicon of an L2 learner. Recently, the topic of how L2 phono-lexical representation are updated has gained more attention; therefore, it is timely to revisit previous findings and evaluate opportunities for further research. Through an analysis of findings across 13 primary studies, this synthesis presents some preliminary answers on two core topics 1) the source of asymmetries in learners lexical decision patterns, as well as 2) the question of whether and how initially inaccurate phono-lexical representations can be updated. Numerous reports confirm asymmetries in lexical access of L2 learners. We argue that inaccurate perception alone cannot explain the reported asymmetries, while they may indicate non-target-like encoding of difficult contrasts in the lexical representations. Based on recent evidence (Darcy & Thomas, 2019; Llompart, 2021), we suggest that old and new phono-lexical representations seem to co-exist, while new representations are more target-like. Finally, drawing on the findings from this synthesis, we will propose some pedagogical implications.

Key words: bilingual mental lexicon, inaccurate phonetic perception, asymmetric lexical access, encoding phonological contrasts, updating phono-lexical representations.

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1. Introduction

Listening to a podcast or understanding an announcement on public transport are quite simple tasks in our native languages (L1), but they prove much more difficult in a second language (L2). Phoneme inventories and phonotactic constraints are language-specific, which poses challenges to L2 learners. For example, the contrast /e/ - /ɛ/ is difficult for L1 Spanish learners of Catalan in part because their L1 Spanish phoneme inventory lacks /ɛ/, a vowel specific to Catalan. The distinct phonetic repertoires between L1 and L2 have consequences for speech perception. How do learners process such new or unfamiliar sounds in an L2? What processes occur during the encoding of phonological representations into the mental lexicon? Over the past 20 years, numerous perception studies have been conducted, as well as a handful of reviews in L2 speech acquisition, such as Thomson and Derwing (2005) on the effectiveness of pronunciation instruction. Most recently, areas such as updating of phono-lexical representations have received more attention (e.g., Darcy & Thomas, 2019; Llompart, 2021). However, to date, no review has been conducted specifically on the topic of encoding contrasts into the mental lexicon of an L2 learner. The purpose of this MA thesis is to be a contribution towards filling that gap. Following Norris and Ortega (2006), its main aim is to answer particular research questions so that findings across individual primary studies can be compared and combined. Therefore, this paper will synthesize the findings of 13 empirical studies that contribute to at least one of the research questions presented in full in Section 4.1.

This synthesis will investigate two research questions (RQs) based on existing research. RQ1 is based on evidence that suggests that learners show asymmetrical patterns of lexical access, where discrimination performance is better for one member of a difficult L2 contrast compared to the other. It will review studies that address the effect that imprecise lexical representations, or conversely, inaccurate phonetic perception has on such reported asymmetries in lexical access. RQ2 addresses the updating of phono-lexical representations: Can initially inaccurate representations be updated? It is concerned with further issues such as: Do old and new representations coexist, or do they develop gradually? Are “improved” phonological representations updated for all words simultaneously, or is the process specific to individual words at a time? Further, how do those processes interact? Additional, speech external factors such as orthography will be discussed throughout where applicable. This synthesis shall provide insight

into the body of research available and present some first answers through comparing and combining findings across the studies that were examined, as well as offer some pedagogical implications.

The paper is divided into three sections. The first part will contain some theoretical background on the nature of L2 phono-lexical representations, processes in bilingual word recognition, the influence of L1 phonological processing on the establishment of L2 phono-lexical categories, and a brief overview of the two most well-established L2 speech perception models. The second, main part of this paper targets specific research questions on L2 phono-lexical representations to provide a synthesis of evidence from recent publications. The third part offers some implications for the classroom, provides a discussion, conclusion of the outcomes from this synthesis including some limitations, and makes some suggestions for further research.

2. Methodology

The thematic scope of this synthesis includes studies in L2 perception that contribute to the understanding of the encoding of phonological representations in the mental lexicon of adult L2 learners. The section containing a review on speech learning models focuses on two of the most established speech learning models (PAM, SLM) and their successors (PAM-L2, and SLM-r) due to their relevance for the encoding of L2 phonological representations and considering that most of the research available in the field has been conducted in view of those models.

The articles were found using a two-step literature search process: 1) a key word search, and 2) a citation search. The key word search involved manual searches of the databases Journal Storage (JSTOR), Linguistics and Language Behavioral Abstracts (LLBA), Wiley Online Library, and Google Scholar. The following key words were used for this initial search: phonological representations, phono-lexical representations, lexical representations, lexical encoding, word recognition, auditory perception, encoding phonological contrasts, asymmetric lexical access, malleability, inaccurate phonetic perception, and form-to-meaning mapping. The terms *L2*, *second language*, or *nonnative* were added to the above key words to classify search results. After this initial key word literature search, some additional studies were consulted through a citation search.

This two-step search process initially yielded around 100 studies concerned with the encoding and updating of phono-lexical representations. These studies were then reviewed to determine whether they were relevant to the specific research questions.

To be included in the synthesis, an article needed to meet the following criteria: 1) be peer-reviewed, 2) be published between 2001-2021, 3) measure L2 acquisition of adolescents or adults, and 4) contribute to at least one of the RQs (see Section 4.1). This timeframe was set because it allows for an examination of comparable research starting from Pallier, Colomé, and Sebastián-Gallés (2001) up to the time this synthesis was conducted. Pallier et al. (2001) is frequently cited as the first to employ a lexical decision paradigm to detect asymmetries when investigating the lexical encoding of a difficult contrast. Excluding studies that involve establishing difficult L2 contrasts in children was done to limit the effects of introducing age as an additional variable.

Finally, 13 studies were selected for synthesis through this procedure for the purpose of finding preliminary answers to the RQs, which are marked with an asterisk in the reference list. Additional studies were analyzed in detail for the first part of this thesis to provide theoretical background information (see Section 3). Supplementary sources were consulted and referenced for contextualization throughout this paper. The list of references provides a full list of the covered literature.

3. Theoretical Background (Part 1)

This first part will provide an overview of some background information on perceptual L2 speech processing, word processing mechanisms, and some of the main theoretical models of L2 speech perception regarding the lexical encoding of L2 phonological contrasts.

3.1 Defining representations in the mental lexicon

Before describing the processes underlying L2 speech perception, some key concepts essential to the encoding of phonetic contrasts in the mental lexicon will be described and defined. When perceiving speech in an L2, new words – as well as the sounds they contain – need to be stored and kept accessible and retrievable within the mental lexicon. During the word recognition process, auditory input is converted and will finally be encoded as phonological representations in the mental lexicon.

According to Hayes-Harb and Masuda (2008), a LEXICAL REPRESENTATION is "the storage of a word in memory" (p.7), which "contains information about the phonological, morphological, syntactic, semantic and, when available, orthographic structures of the word". It appears that phonological information only forms a small part of what a learner needs to master to demonstrate target-like lexical representations.

What kind of phonological information does a learner need to be aware of when learning new sounds in an L2? What exactly is this phonological information that is stored in a learners' lexical representation? According to Boersma (2012), PHONOLOGICAL REPRESENTATIONS consist of elements of temporal organization (e.g. syllable, mora, segment), and elements of "internal content" (p.1) (e.g. phonemes such as /r/, or feature values such as [+nasal]).

Finally, Cook, Pandža, Lancaster, and Gor (2016) define PHONO-LEXICAL REPRESENTATIONS as "the phonological representation of the word as a whole" (p.2). Whether learners manage to encode L2 phonological representations can be empirically tested through an analysis of their phonetic discrimination abilities and lexical decision patterns, as well as fixation duration and patterns emerging from a visual world paradigm using eye-tracking technology.

Cook et al. (2016, p. 3) define a word's FUZZY LEXICAL REPRESENTATION as "a mental representation of a phono-lexical form that does not represent the word as a fixed phonological sequence". Some studies have shown that their L2 listeners' lexical representations were not accurate, but lacked phonetic detail (e.g. Darcy, Daidone, and Kojima, 2013; Darcy & Holliday, 2019; Cook et al., 2016). As a result, phonetic categories were said to be encoded into lexical representations inaccurately, or in a fuzzy way. Fuzzy representations often seem to occur in L2 words with low familiarity. It appears that even L2 phonological contrasts that are not deemed difficult can have fuzzy representations, which may be partly explained by the limited input learners receive (Cook et al., 2016; Gor, 2018).

This section has defined some of the key concepts that are relevant to the encoding of phonetic contrasts in the mental lexicon. The next section will analyze the processes that occur during phono-lexical encoding and how they relate to the difficulties that L2 learners face.

3.2 Accurate phonetic perception and target-like L2 lexical representations

It has been widely reported that L2 learners have trouble to accurately distinguish between members of a difficult phonetic contrast, which may result in errors during lexical decision (i.e. they have trouble deciding whether the input they heard is a word in the L2 or not). What needs to happen for a learner to resolve this difficulty?

Llompart (2021) outlines two interrelated goals that must be achieved. One goal is for learners to be able to identify both members of the contrast as two different non-native phonetic categories. This requires target-like perceptual discrimination for the contrast. In other words, the

learner needs to be able to hear a difference between the two sounds. Secondly, the L2 sounds need to be mapped onto L2 words that contain them. For example, a learner must encode the vowel /ɛ/ into the phonological representation of *lemon (*whereby *lemon* itself is the lexical representation). This process of mastering target-like encoding of phonetic categories into lexical representations is referred to as PHONO-LEXICAL ENCODING.

There does not seem to be consensus on the sequence in which learners have to achieve those two goals. Can lexical representations be established before learners have managed to perceive contrasts accurately? Some researchers (e.g. Pallier et al., 2001; Weber & Cutler, 2004, Broersma & Cutler, 2011) assume that learners must achieve accurate phonetic discrimination of a contrast first. If this has occurred, phonological contrasts can be encoded into their lexical representations in a target-like manner. In Pallier et al. (2001), early sequential bilinguals treated minimal pairs differentiated solely through a difficult contrast as homophones. Proponents of this line of thought would argue that such learners had not managed to establish target-like lexical representations because they had not perceptually mastered the contrast.

On the contrary, other researchers have reported that learners can, in fact, lexically encode contrasts accurately, even when they show poor discrimination performance on the contrast in question (e.g. Darcy et al., 2013; Darcy & Holliday, 2019; Cook et al., 2016). It is argued that learners can rely on other mechanisms, such as orthography or metalinguistic knowledge to establish a lexical contrast. Thus, proponents of this line of thought argue that accurate phonetic perception is not a prerequisite for establishing target-like lexical representations. Section 4.2 (RQ1) will analyze this issue of inaccurate input perception versus imprecise lexical representations on the level of lexical access.

3.3 Word recognition processes in bilingual speakers

This section outlines how bilingual speakers store and access their lexical representations. Generally, the process of word recognition involves the activation of several lexical candidates until the entry with the best overlap between input and lexical representation wins (Norris, 1994). In the L1, the link between auditory perception and lexical encoding, access and retrieval therefore seems to be relatively straightforward and relies on matching the input to the lexical representations in the mental lexicon. The matter is more complicated for an L2 learner, since their

pre-existing L1 categories could interfere during processing and result in slowing, or worse, inhibiting word recognition in the L2.

Are bilinguals' lexical representations stored separately for each language (language-selective access)? Or is there a single, integrated mental lexicon where L1 and L2 words are stored and retrieved together (language-nonselective access)? Models such as the Bilingual Interactive Activation (BIA) (Van Heuven, Dijkstra, and Grainger, 1998) and its revised and updated BIA+ (Dijkstra & Van Heuven, 2002) are based on the principles of language-nonselective access. In such an integrated lexical system, competition effects across both languages can be expected.

What are the consequences for L2 word recognition if all lexical entries are stored in a common space? Do bilinguals manage to suppress lexical candidates that do not match the language of the input? Evidence from research shows that lexical items from both languages can enter lexical competition and slow L2 word recognition (Broersma, 2012; Broersma & Cutler, 2011; Weber & Cutler, 2004). Van Hell and Dijkstra (2002) show that cross-linguistic effects in word recognition may arise in both, a bilingual's dominant and non-dominant languages. Marian and Spivey (2003) provide eye-tracking evidence to demonstrate that when presented with input from one language, bilinguals experienced competition from both languages. However, early sequential bilinguals in Antoniou, Tyler, and Best (2012) demonstrated patterns indicating that while their categorization performance relied on whichever language was activated, bilinguals' discrimination abilities constantly referred to their dominant language, which might partially be explained by the participants' "unique language learning and usage histories" (p.592). Weber and Cutler (2004) showed that L1 vocabulary was a source of additional lexical competition in the L2. In their study, learners' eye movements were analyzed to see which items they looked at, or fixated. There was increased fixation if the L1 name for a distractor was similar to the name of the target image in the L2 – however, when target and competitor roles for confusable contrasts in L1 and L2 were switched, the activation effect diminished. Therefore, contrary to findings in Marian and Spivey (2003), who reported competition from both languages for bilinguals, L2 competitors only seemed to have a strong effect on word recognition when the L2 was the dominant language.

Is the word recognition process in bilinguals affected by whether phono-lexical representations are encoded accurately? According to the *Fuzzy Lexicon* hypothesis (Cook, 2012; Cook & Gor, 2015), accuracy and speed of lexical access are influenced by the degree of detail in L2 phono-lexical representations. Cook et al. (2016) claim that their learners demonstrated fuzzy

L2 phono-lexical representations, which in turn lead to increased competitor activation and slower judgements on confusable words.

Based on the literature reviewed in this section, bilinguals' access to the mental lexicon seems to be language-nonselective. Consistent L1-L2 parallel activation patterns suggest that entries from both languages are stored in a single mental lexicon. Compared to monolinguals, bilinguals seem to experience overall greater lexical competition. Bilinguals seem to mainly experience competition from their dominant languages, although conflicting findings have been reported. There is some indication that inaccurate L2 phono-lexical representations could play a role in lexical access of bilinguals. The factors that influence the effects of language dominance for lexical competition in bilinguals provide opportunities for further investigation.

3.3 L1 influence on the acquisition of L2 phono-lexical representations

Under normal listening conditions, adult native speakers can perceive input accurately and they demonstrate well-established phono-lexical representations. Several factors add to the complexity of L2 phonological processing. This section shall investigate how the acquisition of L2 phono-lexical representations is influenced by the L1.

The speech perception models PAM-L2 and SML-r (see Section 3.4 below) both assume that at initial stages of L2 acquisition, perception of L2 phones is based on their similarity to L1 phones. Besides phonetic proximity to L1 sounds, phonotactic grammar (e.g., how many phonemes are allowed in specific positions?), also influences L2 learners' phono-lexical representations. Indeed, learners' lexical representations for L2 words have been shown to reflect the phonotactic grammar of their L1 (Weber & Cutler, 2006; Ota, Hartsuiker, and Haywood, 2009; Darcy & Thomas, 2019).

As we have also seen in the previous section, L1 influence has been demonstrated to cause increased lexical competition in the L2 (cf. Ota et al., 2009, Broersma & Cutler, 2011; Darcy et al., 2013). Beyond the level of word recognition, L1 influence during perception could lead to "under-differentiation of lexical entries" (Darcy & Thomas, 2019, p.3). Such under-differentiation could lead to two distinct words being stored as homophones, given they are separated solely through a difficult phonemic contrast. Pallier et al. (2001) investigated L2 perception difficulties targeting such difficult minimal contrasts through a (repetition priming) lexical decision task (LDT), where Spanish-dominant bilinguals processed Catalan words with difficult contrasts as

though they were homophones. Similar homophony effects attributed to the absence of well-defined categories were also found in Darcy, Dekydtspotter, Sprouse, Glover, Kaden, McGuire, and Scott (2012).

To summarize, it appears that learner's lexical representations of L2 words are influenced by L1 phonotactic grammar and at least initially, it is proposed that perception of L2 sounds is based on phonetic similarity to the L1. Overall, L1 influence seems to have adverse effects for L2 discrimination accuracy and could lead to difficulties establishing target-like L2 phono-lexical representations.

3.4 The effect of category shifts on the acquisition of L2 phono-lexical representations

So far, we have not considered that some of the difficulties that arise during speech perception stem from how variable the input itself is. Llompart and Reinisch (2019) mention signal distortions arising from noise surrounding speech, but also dialectal variation or foreign accents as sources of variability in the input. In the L1, it appears that listeners use lexical knowledge to shift the boundaries between two phonetic categories to make up for the difference the variability has caused. When it comes to sounds that are not perceptually difficult to discriminate, L2 learners seem to use similar mechanisms, thus using categorization shifts to be able to discern a distinction, even if variability is high (see e.g., Reinisch, Weber, and Mitterer, 2013)

Is the same true for difficult L2 contrasts? How flexible are L2 learners in their perception of difficult contrasts in their L2? It shall be investigated what influence learners' flexibility and resulting category shifts have on how well learners manage to distinguish between the members of the contrast.

To test empirically how robustness of phono-lexical encoding relates to learners' perceptual flexibility, LDT measures can be compared to results from a distributional learning task, which require a learner to categorize sounds on a continuum (e.g., ranging from /ɛ/-/æ/). Exposure phases before learners are asked to categorize the sound aim at perceptually biasing listeners towards one of the response options that is located on the continuum. We can see how well learners manage to adapt and perform a category shift by comparing learners' different category boundary location after each of the exposure phases. One methodological advantage of using a distributional learning task is, as pointed out by Llompart and Reinisch (2019), that

orthographical effects can be ruled out given that such tasks are merely based on categorizing learner's perceptions of a specific contrast.

Learners who demonstrate more phonetic flexibility on difficult contrasts are hypothesized to have more robustly encoded phono-lexical representations. Findings from Llompart and Reinisch (2019) suggest that learners who demonstrated robustly encoded categories were better at LDTs as well, indicating target-like lexical encoding of the difficult contrast. On the contrary, learners who had fuzzy phono-lexical representations showed less boundary shifting in distributional learning tasks.

While we have seen some indication that robust encoding of categories relates to phonetic flexibility, evidence from further studies would need to be gathered to fully evaluate the role of phonetic flexibility for the encoding of phono-lexical representations.

3.5 Models of L2 Speech Perception

The following section will present some of the main models of L2 speech perception in light of lexical encoding of L2 phonological contrasts, alongside some empirical evidence. Both, PAM and SLM aim at explaining the degree of difficulty for mastering L2 sound contrasts. They assume that the degree of learning success in perceiving and producing L2 sounds is, amongst other factors, dependent upon the phonetic (dis)similarity between L1 and L2 segments.

3.5.1 Speech Learning Model (SLM) and Revised Speech Learning Model (SLM-r)

(Flege, 1995; Flege & Bohn, 2021)

The *Speech Learning Model (SLM)* (Flege, 1995) discusses the perception and production of language-specific phonetic segments, rather than contrasts. In general, category formation is said to depend on whether learners can discern phonetic differences between the L2 and L1 sounds that are closest in phonetic space, which was said to be affected by the age of first L2 exposure. Therefore, sounds that are identical between L1 and L2 will be learned with ease; new and dissimilar sounds will be more difficult; whereas L2 sounds that are very similar to L1 sounds will cause the most perceptual problems and subsequent difficulty in acquisition, since a new phonetic category will have to be established. Aoyama, Flege, Guion, Akahane-Yamada, and Yamada (2004) provide evidence from a one-year-longitudinal study of L1 Japanese children and adults to demonstrate that if two L2 sounds differ in perceived dissimilarity from the closest sound in L1

phonetic space, the sound that is more dissimilar (i.e., /ɹ/) will pose more difficulty to acquire than /l/.

One of the central elements of the SLM that seems especially relevant to the updating of phono-lexical representations (see Section 4.3) is that it predicts that, given sufficient exposure, L2 learners have the ability to create new phonological representations because speech processing mechanisms remain accessible to learners all throughout their lifespan.

The *Revised Speech Learning Model (SLM-r)* by Flege and Bohn (2021) focuses on the reorganization of an individual learner's phonetic system as a function of the phonetic input they are exposed to in naturalistic learning settings. It assumes that L1 and L2 subsystems exist and interact with each other in a common phonetic space. L2 learners, no matter their age, use the same L2 speech acquisition mechanisms that were in place for their L1s when they were children.

SLM-r mentions two factors that help account for some of the differences that arise between L1-L2 sound acquisition. First, L1 sounds can temporarily act as a source of interference until new L2 categories are established. Secondly, SLM-r points out that input is important for the establishment of new L2 phonetic categories, which tends to differ drastically between monolingual native speakers and L2 learners. Of methodological interest is the introduction of a parameter that could be used alternatively to the traditionally reported length of residence (LOR) measure. Years of full-time equivalent (FTE) input are calculated as years of residence multiplied by self-reported proportion of daily L2 use.

SLM-r describes the development of a new L2 phonetic category as a gradual, three-stage process. Initially, the differences between L2 and its closest corresponding L1 sound should be noticed. Then, a merged category, or L2 equivalence class will be linked with the closest L1 category, which will be separated in a final step, thus allowing the development of a new L2 phonetic category. This middle stage where no new categories are formed yet, and merged categories still reflect L1 and L2 properties could be a source of explanation for some of the asymmetries in lexical access that have been reported and will be discussed through RQ1.

As part of this gradual process, newly formed L2 categories dissimilate from their closest L1 counterparts to maintain the phonetic contrast. This has been demonstrated by Flege et al. (2003), where participants with early arrival in Canada and low continued use of L1 had formed new L2 phonetic categories for English /e/ that dissimilated from their corresponding L1 category for /e/.

SLM-r lists three factors that determine the likelihood of new L2 phonetic category formation. First, the degree of perceived phonetic dissimilarity between an L2 sound and its closest L1 counterpart. While this factor is important for category formation, it might pose a challenge for empirical research because "it remains to be determined how to best measure cross-language phonetic dissimilarity" (Flege & Bohn, 2021, p.33). The second factor is the precision with which the L1 category has been established at the time of first exposure to the L2 sound. The learner is hypothesized to be more likely to establish a new L2 category if the L1 category has been established precisely at the time of first exposure to the novel sound (*Category Precision Hypothesis).* Preliminary evidence for the effect of L1 category precision on L2 can be found in Kartushina and Frauenfelder (2014). Participants who demonstrated little variability in how they produced L1 vowels were more accurate in identifying phonetic differences between L1-L2. Finally, SLM-r also hypothesizes that another factor for new category formation is the quantity and quality of received L2 input.

To sum up, SLM-r hypothesizes that language-specific phonetic categories are established through the identification of differences between L1 and L2 categories. Of particular relevance to this synthesis are its insights into the processes of new L2 category formation are said to depend on the degree of perceived L1-L2 (dis)similarity, L2 input, and L1 category robustness. SLM-r describes L2 category formation as a gradual process, which in turn could apply to the mechanisms in place for how initially inaccurate representations could be updated (see RQ2).

3.5.2 Perceptual Assimilation Model (PAM) and Perceptual Assimilation Model of Second Language Speech Learning (PAM-L2)

(Best, 1995; Best &Tyler, 2007)

The *Perceptual Assimilation Model (PAM)* predicts how naïve monolingual listeners perceive non-native sounds. PAM assumes that phonetic (dis)similarity to L1 categories determines the degree of success for the discrimination performance on novel L2 sounds. Upon exposure to a novel L2 sound, listeners are likely to "[…] perceptually *assimilate* the nonnative phone to the most articulatorily-similar native phoneme" (Best & Tyler, 2007: p. 22). PAM suggests that initially established phonological categories for the L1 are subject to perceptual readjustments and can take on phonetic details of the L2.

The *Perceptual Assimilation Model of Second Language Speech Learning (PAM-L2)* (Best & Tyler, 2007) extends its predictions to learners in the context of SLA in an immersion context

(as opposed to functional monolinguals). PAM-L2 posits a shared L1 and L2 perceptual system where L2 contrasts are assimilated into the L1 phonological system. Ideal L2 perception presupposes that learners can detect phonetic differences in contrasting L2 phonemes. Learners are assumed to be able to accurately discriminate L2 contrasts if a) the difference in the L2 contrast is the same as in a corresponding L1 category, in which case PAM-L2 suggests that the categories will merge into a joint L1-L2 category; or b) a new, separate L2 phonological category is established. Where L1 phonological categories are not a good match for an L2 contrast, the learner needs to undergo perceptual learning to be able to detect the L2 phonological contrast.

Tyler (2019) states that "initial experience with the L2 sets the trajectory for perceptual learning" (p.617). This initial experience also influences a learner's likelihood to establish a new L2 phonological category. In this case, PAM-L2 argues that having a large L2 vocabulary might cause reinforcement of non-target-like phonological categories, while differences in how L1 and L2 sounds are orthographically represented might contribute to this.

Bundgaard-Nielsen, Best, and Tyler (2011) argue that lexical development can assist L2 phonological acquisition in early stages of L2 acquisition in immersion contexts. In their study, learners that had larger vocabularies were able to achieve more consistent L2-L1 vowel assimilation and more accurate cross-boundary discrimination than those with smaller vocabularies. Llompart (2021) tested the relationship between L2 vocabulary size and phono-lexical encoding outside of an immersion setting in intermediate and advanced German learners of English. Based on PAM-L2, a large L2 vocabulary was hypothesized to be related with more instances of inaccurately encoded phonological representations. However, their study provides evidence for a hypothesis that was proposed based on findings from Bundgaard-Nielsen et al. (2011), regardless of the different learning contexts (immersion context vs. classroom). Llompart (2021) found that learners with a larger vocabulary size demonstrated more target-like phono-lexical encoding of the contrast in question. Advanced learners achieved higher vocabulary scores and more reliable phono-lexical encoding of the critical contrast. Their vocabulary test scores predicted success in rejecting nonwords with a member of a difficult contrast. Therefore, contrary to PAM-L2 suggestions, there may be some indication that vocabulary expansion in the L2 "contributes to approximating native phono-lexical encoding for difficult L2 contrasts" (Llompart, 2021, p. 490). However, those results should be interpreted with caution, given they were based on one learner group and a single contrast. It seems that further research is needed to investigate

the relationship between an early expansion of L2 vocabulary size and the encoding of difficult contrasts into their lexical representations in learners outside of immersion contexts.

In addition to the importance of vocabulary size, PAM-L2 points out the importance of exposure to input that provides the learner with clear phonological differences, which, according to PAM-L2, does not necessarily imply *native* input. Exposure to such input is conducive to the establishment of new L2 categories and is deemed crucial to ensure that learners can perceive a difference.

An interesting addition comes from Wrembel, Marecka, and Kopečková (2019), who expand PAM-L2 to account for the effects of multilingualism. The authors predict that adolescent L3 learners would show similar patterns as hypothesized by PAM (Best, 1995; Best & Tyler, 2007), whereby L3 vowels are perceptually assimilated to both L1 and L2 categories in a cross-linguistic similarity rating task. Participants demonstrated that they managed to maintain a distinction in how they perceive L3 vowels in relation to similar L2 and L1 vowels, thus indicating that their categories were not completely merged. However, it was found that more L3-L1 vowel pairs, compared with L2-L1 pairs were judged as perceptually distant. Multilinguals seemed to have assimilated L3 sounds more readily to the L2.

To conclude, it appears that cases in which two L2 sounds are mapped onto the same L1 phonological category (i.e., single-category assimilations; Best & Tyler, 2007) are quite problematic for late L2 learners, which results in difficulties to perceptually distinguish the two L2 contrastive sounds. Further, PAM-L2 states that a large L2 vocabulary during early stages of L2 acquisition might be detrimental to the establishment of target-like phonological representations, resulting in potential fossilization, a view which is challenged by Llompart (2021). PAM and PAM-L2 are relevant for investigating the nature of L2 phono-lexical representations because it could help explain some of the difficulties that learners experience when acquiring L2 contrasts in relation to the perceived (dis)similarity within their L1 phonological space.

4. Encoding of L2 phono-lexical representations (Part 2)

Having reviewed some of the theoretical background, the following section will be reviewing findings from empirical studies relating to the research questions outlined below.

4.1 Research Questions

RQ 1: What role do imprecise lexical representations and inaccurate phonetic perception play for asymmetrical lexical access in L2 learners?

RQ 2: Can initially inaccurate phono-lexical representations be updated? How do such updating processes occur?

4.2 RQ1: Asymmetries in L2 lexical access

Some L2 contrasts can cause more perceptual difficulties than others. Further, the level of difficulty can even vary between the members of such a contrast, which may lead to a more accurate discrimination performance for one member compared to the other – a lexical decision pattern commonly referred to as asymmetrical lexical access. Before examining findings that help us understand the role of imprecise lexical representations and inaccurate phonetic perception for asymmetrical access in L2 learners, it is worth considering why asymmetries in L2 lexical access are relevant for the encoding of phonological contrasts into the mental lexicon. Generally, findings of asymmetries are notable because they may be an indicator of non-target-like phonological encoding in the lexical representation.

4.2.1 Detecting asymmetries in L2 lexical access

At this point, it is worth investigating how such asymmetries in L2 lexical access can be detected. Two ways are commonly utilized: 1) analyzing the fixation patterns using eye-tracking by means of the visual world paradigm, and 2) analyzing participants' results from auditory (LDT)

Methodologically, assessing asymmetries through eye-tracking has the advantage that it allows us insight into processing mechanisms during word recognition even before the final lexical candidate has been selected. Dahan, Magnuson, Tanenhaus, and Hogan (2001) argue that eye movements reveal effects of lexical competition that would be obscured in patterns emerging from lexical decision tasks.

Based on Weber and Cutler (2004), the following outlines a commonly used procedure using a visual world paradigm. Dutch learners find the English contrast /æ/-/ɛ/ difficult to perceive. They receive an auditory stimulus that targets an item in the L2, such as "click on the *p**a**nda"*, and are presented with a grid containing images of the target, as well as some fillers and distractors. One distractor, e.g. *p**e**ncil,* contains a member of a difficult vowel contrast which is likely to be

confused with a vowel in a target picture name, i.e. *p**a**nda*. Learners should experience increased competitor activation if they fixate confusable distractor pictures more often and longer than fillers containing distinct vowels. However, this still would not indicate asymmetries. In a second step, it is analyzed whether learners fixate a target item such as *c**a**talog* (containing difficult /æ/) when presented with a distractor that contains the other member of the contrast /ɛ/ (e.g. *k**e**ttle*) significantly more often compared to how often items containing the other member /ɛ/ activate *c**a**talog*. Therefore, it is hypothesized that both members of the difficult contrast /æ/-/ɛ/ are mapped onto the dominant category /ɛ/ (which is acoustically similar to L1 /ɛ/).

Another way of detecting asymmetries in lexical access, as employed by Darcy et al. (2013), is through analyzing learners' category discrimination performance in the ABX tasks and comparing them to their auditory LDT accuracy scores by means of a linear mixed effects model yielding consonant type (new, old) and lexical status (word, non-word) as fixed factors and mean accuracy as the dependent variable. If no asymmetries were present, such as for a native control group, a main effect of lexical status, no effect of consonant type and no interaction is expected. However, if learners show a main effect of lexical status, no effect of consonant and a significant interaction between lexical status and category type, this would indicate asymmetries for words containing the dominant (old) vs. non-dominant (new) category.

Evidence from research suggesting that learners show asymmetrical patterns of lexical access, where discrimination performance is better for one member of an L2 contrast than for the other, is numerous (e.g. Weber & Cutler, 2004; Cutler, Weber, and Otake, 2006; Escudero, Hayes-Harb, and Mitterer, 2008; Broersma & Cutler, 2011; Darcy et al., 2012, 2013, Melnik & Peperkamp, 2019; Llompart & Reinisch, 2019) and involves learners with different language backgrounds and difficult contrasts involving consonants as well as vowels.

4.2.2 Inaccurate perception as the source of asymmetrical lexical access

So far, we have established numerous reports of learners with asymmetrical lexical access on difficult L2 contrasts. Now we will examine some explanations of why such asymmetries occur. Some authors outlined in Section 4.2.1 (e.g. Cutler et al., 2006) argue that the learners in their experiments seemed to have achieved a lexical distinction for the difficult contrasts, but that instead, the problem is inaccurate perception.

This line of reasoning states that if lexical representations were indeed inaccurate, the vowel in the input would have corresponded to the vowel in the lexical representation, which in turn should have deactivated the non-target-like competitor. It is assumed that no matter which member of the contrast is acoustically presented, only words containing the dominant member receive initial activation. This will be further illustrated through findings from Broersma and Cutler (2011), who examined the role of near words extracted from word or phrase contexts with the aim of investigating more closely resembling natural situations, as opposed to "laboratory-constructed" input. Choosing to use stimuli that consist of occurrences that are embedded in real words appears to be motivated by the fact that "distinguishing homophones is probably not the most significant L2 listening problem" (Broersma & Cutler, 2008, p.31).

In Broersma and Cutler (2008), the sequence *daf-*, extracted from the word *daffodil*, activated the word *deaf* in Dutch listeners. It appears that even competitors that matched a larger part of the input were unsuccessful at disabling the near word containing the misperceived vowel as a strong lexical candidate. When learners were presented with *definite*, the activation of *deaf* diminished as soon as the whole word had been presented. Crucially however, even after the whole word *daffodil* had been heard, *deaf* remained activated. When analyzing their data, it should be kept in mind that it is based on comparisons of response time (RT) on lexical decision tasks without a comparison to learners' categorization performance in an ABX task (as outlined in Section 4.2.1).

It is argued that learners' lexical representations must be accurate because of instances in which lexical candidates could not be deactivated when presented with a sound that was arguably misperceived. This should explain instances in which *definite* successfully deactivated *deaf*, while *deaf* remained active after hearing *daffodil*. The explanation provided is that the initial vowel /æ/ in *daffodil* was in fact misperceived as /ɛ/, which led to initial activation and subsequent failure to deactivate the candidate *deaf*.

What other factors influence asymmetries? It appears that orthography has an impact on lexical asymmetries. Escudero et al. (2008) found that learners who were aware of the orthography of the words displayed asymmetrical lexical activation – an effect which diminished in learners that were merely exposed to auditory forms. Through the example of Japanese /l-r/, we will revisit two factors in more detail that could help explain the dominance of one member over the other: 1) orthography and 2) phonetic proximity to L1 category.

In Japanese learners who have difficulties to distinguish between /l-r/, it appears that /l/ should emerge as the dominant category due to its articulatory proximity and better goodness of fit to Japanese /ɾ/, whereas /r/ would be more difficult to acquire – a pattern which agrees with SLM predictions. On this same contrast, Cutler et al. (2006) argue that if orthography should play a role, however, /r/ should emerge as the dominant category instead. This is because Japanese/ɾ/ is represented as the letter *r*. In Cutler et al. (2006), the effect of orthography could be ruled out, while the authors state that "acoustic-phonetic proximity to the L1 category […] is the deciding factor in determining which of the two L2 categories is dominant" (Cutler et al., 2006, p. 282), thus ruling out an orthographic effect and suggesting that /l/ was a better match to the participants' L1 category than /r/ was.

To return to our initial question: Can imprecise perception alone explain such asymmetries that cannot be attributed to inaccurate lexical representations? It seems plausible that misperception contributes to a lack in deactivation of lexical candidates, though more cases would have to be studied to support that claim. Even if that is the case, the patterns observed could merely be an example of asymmetries reported in numerous other studies, rather than providing an explanation for them. Therefore, it seems that overall, there is not sufficient evidence that imprecise perception alone can explain asymmetries, and secondary factors such as orthography or phonetic proximity to the L1 – which was successful in providing an explanation for the asymmetry that arose in Japanese learners – need to be considered. Further investigations are needed to fully analyze the impact of orthography across different learner groups.

4.2.3 Inaccurate lexical representations as the source of asymmetrical lexical access

This section will outline a different line of reasoning which argues that inaccurate perception alone cannot be the sole cause of asymmetries but sees its source in learners' non-target-like lexical representations. First, results from Melnik and Peperkamp (2019) will be analyzed and used for illustration. Second, theoretical and empirical evidence will be added surrounding the LCD hypothesis (Darcy et al., 2013).

In a recent study, Melnik and Peperkamp (2019) argue that findings of asymmetries in lexical access could not exclusively be attributed to inaccurate perception of /h/, a difficult sound for French learners of English. Mirroring production patterns (/h/ is more likely omitted), learners misjudged nonwords in which /h/ was removed (i.e., ***u****sband*-types) more often than nonwords like

h*officer*. The authors argue that if the asymmetries could exclusively be attributed to inaccurate perception of /h/, French learners should have performed worse on ***h****officer*-type than on ***u****sban*d-type nonwords, contrary to what was found. Simonchyk and Darcy (2017) add that the ability to perceive a difficult contrast is "a foundation for learners to encode this difference in the mental lexicon" (Simonchyk & Darcy, 2017, p. 130), while their findings support the claim that target-like perception alone is insufficient to secure accurate L2 lexical representations containing difficult contrasts. Cook et al. (2016) expand the argumentation of inaccurate phono-lexical representations to confusable words that do not target a difficult phonological contrast.

The studies outlined in this section thus replicate findings from Weber and Cutler (2004) and Cutler et al. (2006) by reporting patterns of asymmetric mapping from phonetic to lexical representations, however, they differ in their argumentation in stating that the source of asymmetry is not imprecise perception, but instead inaccurate encoding of the non-dominant category.

In the following paragraphs, the *Lexical Coding Deficiency* (LCD) hypothesis (Darcy et al., 2013) will be analyzed since its predictions on learners' LDT patterns provide a basis for empirical testing. LCD follows the same argumentation as outlined above by assuming that listeners can correctly perceive the L2 input that does not match a L1 category. In other words, their input perception is accurate. The difficulty is located at the lexical coding level: The lexical representations encode both categories that make up the contrast, although the non-dominant category is encoded in a fuzzy, inaccurate way. The non-dominant category refers to the L1 and could, for example, be encoded as a poor match to the dominant L1 category (cf. Cutler et al., 2006, Hayes-Harb & Masuda, 2008). Based on the LCD hypothesis, the following predictions on learners' lexical decision patterns are made:

Figure 1: LCD hypothesis - Expected LDT performance

	Dominant category (old)	**Non-dominant category (new)**
Words	*easy to accept (1)*	*less easy to accept (2)*
Non-words	*difficult to reject (4)*	*easy to reject (3)*

Figure based on Darcy et al., 2013, p. 378, Figure 1a. Numbers in brackets indicate ordinal accuracy (1=high, 4=low).

How could the LCD hypothesis be empirically tested? For this, let us look at how LDT results could be interpreted. Learners should demonstrate asymmetric lexical decision patterns coupled with a highly accurate categorization performance. Words containing the old category should be easier to accept than ones with the new category. In Darcy et al. (2013), intermediate learners indeed were marginally more accurate for words containing the old category than the new. Advanced learners were (non- significantly) more accurate in recognizing old, as opposed to new words. They rejected non-words containing a new category more accurately than those containing an old category. So did intermediate learners, though again, exhibiting a non-significant trend. Those descriptive patterns follow LCD's predictions, as illustrated by Table 1 above.

Further evidence stems from advanced learners of Russian in Simonchyk and Darcy (2017), who rejected target nonwords containing members of a new category (palatized consonant) more often than nonwords containing members of the old category (plain/non-palatized consonant) – patterns providing empirical evidence for the LCD.

To conclude this section, it is time to look back at our first research question to revisit our findings and provide some preliminary answers. RQ1 was concerned with the role of imprecise lexical representations and inaccurate phonetic perception for asymmetrical lexical access in L2 learners. We first described how asymmetries could empirically be detected, such as through patterns in a visual world paradigm where learners fixate a competitor primed by one member of a difficult contrast systematically more than a competitor primed by the other member of the contrast. Numerous accounts of learners demonstrating such symmetries in lexical access have been reported. Overall, there appears to be a consensus that L2 learners from various language backgrounds have difficulties to perceive difficult contrasts accurately. It remains subject to debate whether such perceptual difficulties coupled with secondary factors such as orthography can explain various reports of asymmetries in L2 lexical access. Based on patterns investigated in the studies outlined above, it seems that the difficulties that L2 learners have in encoding phonetic contrasts accurately into learner's lexical representations contribute to the understanding of why such asymmetries occur.

4.3 RQ2: Updating phono-lexical representations

So far, this synthesis has focused on the nature of L2 phono-lexical representations and the role of imprecise lexical representations and inaccurate phonetic perception for asymmetric

patterns of lexical access. This section focuses on how initially inaccurate L2 phono-lexical representations could be updated – a question that is particularly relevant to learners since such updates ideally result in achieving more target-like perception of affected contrasts.

If lexical representations can be updated, how does this process occur? To date, not much appears to be known about the process. Do old (inaccurate) and new (accurate) phono-lexical representations coexist, or is the development gradual? This section will aim at finding some preliminary answers to those questions.

To approach the subject, let us consider the participants in Pallier et al. (2001), Spanish-dominant bilinguals of Catalan who demonstrated high proficiency and were exposed to Catalan for more than 15 years, and yet, were somehow unable to encode some difficult phonetic contrasts accurately. Perhaps motivated by this, Pallier et al. (2001, p. 448) state that "it seems that this abstract phonological code, once acquired, is hard to modify". Similarly, in Darcy et al. (2012), intermediate L1 English learners of French showed that they processed minimal pairs which differed solely in the difficult contrast /y/-/u/ as homophones. However, the advanced learner group showed no facilitation effects for minimal pairs of both contrasts during lexical decision, thus indicating that they had managed to accurately encode the contrasts into learners' lexical representations (even though they still had difficulties to perceptually discriminate them). Although these observations were not made longitudinally within the same group, but rather through a comparison of two learner groups that differed in proficiency, Darcy et al. (2012, p.29) state that "spurious homophony can be resolved with more experience", thus giving us some hope that perhaps inaccurate representations do have the potential to be updated.

Overall, more advanced learners seem to outperform lower-level learners in LDT (Darcy et al., 2012, 2013; Darcy & Thomas, 2019). Based on those findings, it seems possible for learners with more L2 experience to form lexical representations that were not present at earlier stages of acquisition. As we recall, PAM and SLM both assume that learners can create new phonological representations because speech processing mechanisms remain accessible to learners all throughout their lifespan.

4.3.1 The influence of initial L2 experience on the updating process of phono-lexical representations

This section aims at analyzing how initial L2 experience could impact the updating of phono-lexical representations. Why would we think initial L2 experience is relevant for the

updating process? To be able to understand how updating processes occur, we should consider what was important when L2 phonological categories were established in the first place.

As we have seen, PAM-L2 proposed that initial L2 experience is important for perceptual learning and determines how likely a learner is to establish a new L2 phonological category (Flege & Bohn, 2021; Tyler et al. 2019). Therefore, one could ask if time of first exposure to a difficult contrast also plays a role for updating initially inaccurate phono-lexical representations. Darcy and Holliday (2019) provide an explanation for why the time of first word learning could be relevant. As we know, at initial stages of L2 acquisition, words may be encoded with low phonological precision. Not updating those representation could lead to reinforcement or fossilization of non-target-like L2 lexical representations – a pattern which might help explain the low phonetic discrimination performance highly proficient bilinguals reported in Pallier et al. (2001). Further, improvements in perception that were developed at a later acquisition stage could enable more precise encoding of lexical representations. Therefore, the timing of when each word was learned for the first time could be relevant.

A methodological problem might arise: How do we researchers find out when a learner first learned a word? Is it reasonable to assume that learners have enough metalinguistic awareness to remember such details specifically? Darcy and Holliday (2019) operationalized "old" and "young" words as words that were learnt early on versus more recently, which in turn was based on the learners' own assessment through a word familiarity and learning history questionnaire.

Two hypotheses brought forward by Darcy and Holliday (2019) provide contrasting views on how lexical representations are updated. The *Age of Words hypothesis* assumes that updates are dynamic, word-specific, and sensitive to the timing when a given word was learned. Lexical representations that were developed at early stages of acquisition mirror an early perceptual system, and thus are less accurate than more newly encoded lexical representations, a pattern which could be seen in a higher nonword rejection rate for young words. In Darcy and Holliday (2019), such "young nonwords" tended to get rejected more successfully than words that were learned longer ago; patterns which descriptively supports the Age of Words hypothesis. However, the effect of word age did not reach statistical significance.

Conversely, the *Phonological Update Hypothesis* assumes that as soon as a specific vowel contrast was perceived accurately, all the affected lexical representations would be updated simultaneously, regardless of when they were acquired. Darcy and Holliday (2019) provide

tentative support for the Phonological Update Hypothesis, given that the effect of word age was non-significant and that there was no significant interaction between word age and trial type.

4.3.2 Updating in the form of co-existing phono-lexical representations

So far, we have discussed the possibilities that all words receive a simultaneous update as soon as target-like phonetic discrimination is achieved, or that updates could occur word-specific as a function of when they were first learnt. Alternatively, it could also be argued that updates do not occur simultaneously, but are manifested through co-existing lexical representations, whereby some are still inaccurate, and some reflect newly acquired target-like properties.

As previously established, L2 learners' phono-lexical representations are influenced by L1 phonotactic constraints. An example of this are Korean learners of English, who tend to perceive *blue* as [bʊˈluː], adding an epenthetic vowel to match L1 phonotactic constraints (Darcy & Thomas, 2019). It seems reasonable to assume that at least at initial stages of learning, learners might encode an additional epenthetic vowel into the lexical representation. Do all learners, regardless of their proficiency, encode epenthetic vowels, thus resulting in non-target-like lexical representations? Do learners at higher levels of proficiency manage to update their lexical representations?

Patterns emerging from Darcy and Thomas (2019) provide some interesting preliminary answers to this question. As was predicted, most participants had not encoded L2 initial consonant clusters accurately and showed influence from their L1 phonotactic grammar. Some of the participants, however, achieved similar results to native speakers where, at least in some of the trials, they were able to reject items with epenthetic /ʊ/. This variability within participants could indicate that learners might have had co-existing lexical representations; some that displayed inaccurately encoded epenthetic vowels and some that had encoded the clusters accurately. Several potential reasons for the variability, such as proficiency or item familiarity were analyzed, though they could not easily provide an explanation. Generally, they hypothesize that improved perception accuracy would lead to forming some new target-like lexical representations that no longer contain epenthetic vowels. Even though the authors did not explicitly test for the presence of perceptual repairs, they point out that such co-existing representations could help explain the variability in their findings.

In such a scenario, it seems likely that the establishment of target-like phono-lexical representations happens over a long time. While some words have not yet "received an update", learners could demonstrate target-like representations for some items but not others.

4.3.3 Influence of L2 vocabulary size on the updating of phono-lexical representations

Another factor that might have an impact on how phono-lexical representations are updated is L2 vocabulary size. When introducing PAM-L2, the effects of large vocabulary size on how learners establish phono-lexical representations were presented (see Section 3.4.2). Essentially, learners who have a larger vocabulary size have also been exposed to more words that contain difficult phonetic contrasts compared to learners with smaller vocabulary sizes. If we assume that the degree of accuracy in phono-lexical encoding is influenced by vocabulary size, following the rationale of Llompart (2021) outlined in Section 3.4.2, it could be hypothesized that inaccuracies in L2 lexical representations can be reduced by receiving more input.

Does vocabulary size also impact how previously established phono-lexical representations are *updated*? It could be argued that the link between a difficult member of a contrast and previously known words that include the same sound in their lexical representation could be strengthened as more words are added to the L2 lexicon which contain this contrast. Intermediate learners in Llompart (2021) who demonstrated target-like categorization abilities also were more successful at rejecting difficult nonwords. For advanced learners, however, it was found that a larger vocabulary size resulted in marginally significantly faster RTs on a LDT when instructed to reject difficult nonword. Knowing more words therefore might facilitate the substitution of non-target-like phonological representations with forms that are more target-like "in a dynamic relexification process" (Llompart, 2021, p. 490). It appears that Llompart (2021) also interprets their results considering that updating processes occur through temporarily co-existing phono-lexical representations. Further research is needed to provide more insight on the effect of L2 vocabulary size on the updating of L2 phono-lexical representations.

Let us review RQ2 to analyze how L2 phono-lexical representations are updated. Based on findings of advanced learners outperforming lower-level students in LDTs, it seems reasonable to assume that lexical representations evolve as a function of more experience in the L2, and as a result, learners can potentially achieve more target-like L2 lexical representations.

We have seen that the time at which a word was first learned could play a role in the development of phono-lexical representations, however, findings from Darcy and Holliday (2019) merely descriptively supported this view. Instead, they provided tentative evidence that all lexical representations seem to get updated simultaneously. It is crucial for further research to investigate similar effects to confirm and replicate their findings.

Tentatively, we would like to answer RQ2 through recent evidence (Darcy & Thomas, 2019; Llompart, 2021) which indicates that old and new phono-lexical representations can co-exist; learners can thus form new, more target-like lexical representations. Co-existing representations helped explain variability within participants' performances (Darcy & Thomas, 2019). It will be interesting to see whether future research is able to replicate such findings, thus allowing for a more definitive answer.

Lastly, we have also touched on the influence of L2 vocabulary size on the updating of phono-lexical representations, where, based on Llompart (2021), we could tentatively suggest that knowing more words might facilitate the substitution of non-target-like phonological representations with forms that are more target-like. However, more findings would need to confirm this finding to be able to draw definite conclusions. All in all, while these studies give some valuable insight into how phono-lexical representations could be updated, we look forward to more insights provided by future research.

5. Pedagogical implications

This section aims at providing some ideas of foreign language (FL) classroom applications based on some of the findings from this review.

We have seen that, according to PAM-L2, the likelihood of L2 phonological category formation depends on a learners' initial experience. Applied to the classroom, this would mean that students should be subjected to large quantities of input that allow them to detect the phonetic differences that make up the relevant difficult L2 contrast (Tyler, 2019). Exposure to sufficient input that provides the learner with clear phonological differences is conducive to the establishment of new L2 categories. Native speaking teachers are not a necessary requirement to fulfil the goal of forming a new L2 phonetic category that enables learners to differentiate it consistently and reliably from the closest L1 category.

Again, following PAM-L2, each new word might reinforce how the sounds are encoded into their lexical representation. A large vocabulary size might therefore jeopardize the establishment of target-like phonological categories due to its potential to reinforce pre-existing categories. Additionally, if the time at which a new word is learned indeed proves to be crucial to updating more target-like phono-lexical representations, it would make sense for learners to expand their vocabulary only at later stages of acquisition where they could benefit from a more developed perceptual system. Following Tyler (2019), learners should be exposed to plenty of auditory input before a large L2 vocabulary gets established. However, because this view has been partially challenged by Llompart (2021), this matter should be further investigated to ensure that useful classroom practices can be recommended.

According to Darcy and Holliday (2019), new vocabulary should be taught with a focus on pronunciation, whereby previously known words should be revisited often, while again, explicit reference to pronunciation should be made so that learners can focus on the phonological form of the words. Perhaps it could be helpful to introduce new vocabulary to students with the help of a visual learning aid, such as photos or drawings, along with the auditory input, thus avoiding an early introduction of orthographic form. An approach in which the focus is set on pronunciation might prevent the establishment of numerous inaccurate lexical representations to begin with.

6. Discussion and conclusion

The first part of this synthesis has provided extensive theoretical background information focusing on word recognition processes in bilinguals, the effects of L1 influence as well as robustly encoded categories on the acquisition of L2 phono-lexical representations. It presented the main models of L2 speech perception considering their relevance to the encoding of phono-lexical representations. This paper has reviewed the processes underlying the encoding of difficult contrasts into the mental lexicon of L2 learners through a review of findings across empirical studies that relate to the source of asymmetries in lexical decision as well as some of the processes that underly updating initially inaccurate L2 phono-lexical representations.

The first research question was concerned with the role of imprecise lexical representations and inaccurate phonetic perception for asymmetrical lexical access in L2 learners. Numerous accounts of learners demonstrating asymmetries in lexical access have been reported, where L2 learners from various language backgrounds have difficulties to accurately perceive difficult

contrasts involving vowels or consonants and as a result, show stronger performance on one member of the contrast than on the other. Whether target-like lexical representations can be encoded before the contrast can be accurately distinguished remains subject of debate. Perhaps it is more useful to abandon a view in which attention is focused on the sequence in favor of a more holistic view that acknowledges that being able to perceive a difficult contrast is a helpful condition that is beneficial for encoding target-like lexical representations.

The second research question analyzed the updating of inaccurate L2 phono-lexical representations. Based on findings that have shown that advanced learners tend to outperform lower-level learners in terms of their discrimination performances, there is sufficient grounds to assume that learners can potentially update phono-lexical representations which initially had been encoded in a non-target-like way. Darcy and Holliday (2019) hypothesized that the time at which a new word has been learned plays a role in the development of phono-lexical representations, whereby newly learnt words mirror an improved perceptual system that thus reflect more target-like phonetic properties. While this is a hypothesis worthy of further investigation, methodological issues arise when operationalizing when a learner learns a new word. Tentatively, we can answer the second research question based on recent evidence (Darcy & Thomas, 2019; Llompart, 2021) by suggesting that old and new phono-lexical representations seem to co-exist, as opposed to an updating process where representations simultaneously become more target-like. It appears that research examining the issue of updating phono-lexical representations stems from studies that have been conducted very recently, while only a small number of studies were published in general. While we have received some valuable insight into how phono-lexical representations could become more target-like over time, it is crucial that evidence from further research replicates findings from Darcy and Thomas (2019) and Darcy and Holliday (2019) for us to enable a better understanding of the processes underlying phono-lexical updates.

We will conclude this synthesis by discussing some limitations. The first limitation is related to the thematic scope of this synthesis. The RQs were formulated to provide a general overview of the topic of encoding and updating phono-lexical representations. Several aspects, such as the impact of speech-external factors on the encoding and updating of L2 phono-lexical representations were not systematically analyzed. Potentially including a third research question on the topic of how speech-external factors, such as orthography, impact the formation of L2 phono-lexical representations could have added clarity and thematic depth to this synthesis.

Finally, some methodological limitations will be addressed. Following Norris and Ortega (2006), “research synthesis always includes an explicit articulation of how the relevant literature was searched and how primary studies were selected for review” (p.6). While such a description was provided in the methodology section to promote transparency, the key word search and subsequent citation search were performed manually, which lacks the systematic rigidity that is needed to produce an externally valid sample. Additionally, to ensure consistent quality across the studies that were selected, only peer-reviewed studies were included, which, according to Norris and Ortega (2006) comes with the trade-off danger of promoting a publication bias, whereby including only published results could lead to an “inflated view favoring positive and large expected effects” (p. 21).

Word count: 10’444

Note

* The studies that were included in the synthesis for Section 4 are marked in the reference list below with an asterisk.

7. References

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