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Phonology and morphology in lexical processing

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7.1 Introduction

Imagine a non-native listener of English with some English vocabulary internalized, struggling with ambiguous auditory input. Was it road or load? Broadly speaking, there are several possible scenarios. First, the word may not be stored in the mental lexicon of a second language (L2) learner, and the learner decides, “I don’t know this word.” This is a quite common, but the least interesting case. Second, the learner may be hesitant about which word was pronounced because it contained a phonological contrast that made it difficult to tell which of the two similarly sounding words it was, still or steal, rip or reap, or maybe lip or leap? Third, L2 learners quite often misidentify one word as another that sounds similar, but not identical, even in the case when no problematic phonological contrasts are involved. Whisper and whisker, which one belongs to a kitten? And fourth, L2 learners need to decide whether a word is mono- or polymorphemic and decompose morphologically complex words into constituent morphemes in order to process morphosyntactic information: was it guessed or guest, patients or patience? Here, the morphological analysis prompted by sentence structure will achieve two goals: access of the lexical entry and interpretation of the information contained in the inflection, past-tense -ed marker in guessed and plural -s marker in patients. This chapter will review recent findings and discuss new directions in research addressing two major interfaces in L2 acquisition and processing, those of phonology and lexical access and morphology and lexical access. It will focus on lexical access of words presented in isolation and will leave the growing body of research on lexical access in a sentence, as well as the study of word boundary effects and assimilation across word boundaries in phrases, outside its scope due to space limitations.
7.2 Phonological aspects of L2 lexical access

7.2.1 Models of L2 phonetic categorization

Recent years have seen several developments in research devoted to the acquisition and processing of L2 phonology: a long-awaited realization that most research on L2 perception had been dealing with categorization of phones that have no connection to their linguistic function. First, the function of phonemes, abstract linguistic units, is to serve as building blocks of morphemes and words, as they are represented in the mental lexicon. Accordingly, researchers have turned to the phoneme as opposed to a theoretically neuter phone, which is made possible only by focusing on the interface of phonology and the lexicon, as opposed to meaningless segments and sequences. Second, there has been a renewed interest in the phonology–phonetics interface and the study of the interactions of bottom-up and top-down processing. Third, in addition to looking at phonological processing in L2 learners differing in proficiency, age of acquisition, amount of L2 input received, and other biographical non-linguistic variables in order to recreate the developmental learning curve, recent studies report highly controlled vocabulary learning experiments to gain direct insights into how phonological learning and vocabulary learning interact in a bootstrapping fashion. And fourth, this new interest in phonology in lexical access and lexical learning explores the dimension of the phonology–lexicon interface that is extremely important for L2 processing: phonological representations of words and lexical competition, and the impact of unfaithful phonological representations of words on L2 lexical access.

Until recently, theories of L2 phonological acquisition were not overly concerned with how the interaction of bottom-up phonetic and top-down lexical processing leads to the formation of abstract phonological categories, and rather took this interaction for granted. In this sense, they were precursors of the new paradigm in research on phonological categorization in L2 lexical access. This section will review four such theories, all of which explore native and nonnative phonetic categories. The Native Language Magnet (NLM) (Kuhl & Iverson, 1995) model of native (L1) and L2 perception focuses on the properties of the phonetic space in the vicinity of, and at a distance from, the prototype and the perceptual warping phenomenon. According to NLM, the prototype acts as a perceptual magnet attracting the sounds that are close in the perceptual space so that the listener categorizes them as the prototype. This is true of L2 sounds being “caught” in the space of the L1 prototype. The prototype is assumed to be a functional L1 sound unit, and its phonetic properties and the space – usually, the F1/F2 vowel space – seem to refer to the main allophone. NLM has found support with the prototypes of the American English /i/ and /e/, and Swedish /y/. Thus, NLM shows nonlinearities in the
perceptual space that underlie the categorization of new phones based on their acoustic properties and remains agnostic with regard to the phonological status of the phones. Moreover, the NLM model is primarily concerned with early infant perception, before lexical learning and the establishment of phonological categories.

The Speech Learning Model (SLM) (Flege, 1995) aims to account for age-related constraints on the ability to produce L2 vowels and consonants in a native-like fashion. It is concerned with the acquisition of phonetic categories rather than phonological contrasts. SLM states that acquisition of the sound shape of L2 proceeds by establishing perceptual similarity between the positional allophones rather than L1 and L2 phonemes themselves. It is based on (dis)similarity of perceptually linked L1 and L2 sounds, diaphones, with the status of the L2 phone in L2 acquisition depending on the phonetic characteristics of the relevant positional allophones of L1 and L2 rather than the more abstract phonemic level (p. 239). Accordingly, phonological parsing of L2 lexical units remains outside the scope of the model.

The Perceptual Assimilation Model (PAM) (Best, 1995) explores the consequences of perceived similarity between L1 and L2 phones with the phonetic space organized based on articulatory gestures. It finds its origins in Articulatory Phonology, and in this respect, stands apart from the other purely perceptually based models. In its original version, PAM was intended for the situation of the initial cross-linguistic contact and focused on naïve listeners. It is not concerned with how the perceptual space is directly mapped onto the phones, since the model accepts and treats the outcome of such complex categorization process as a given.

PAM has been extended to the situation of L2 acquisition in its PAM-L2 version (Best & Tyler, 2007) that addresses the consequences of exposure to L2. The articulatory–phonetic interface remains the mechanism driving L1 and L2 linguistic perception, though the emphasis has shifted to the developmental aspects of the model.

PAM-L2 was the first to state explicitly that the phonological level is central to the perception of speech by L2 learners. Naïve learners at their first contact with L2 cannot possibly be dealing with L2 phonemes, the units supporting lexical representations and lexical access in a language completely unknown to them. While cross-linguistic research on phonetic categorization of new sounds establishes a much-needed baseline, it is uninformative about phonemic categorization; hence the need for research aiming at the phonological level of L2 closely connected to lexical acquisition.

The most recent model of L2 phonological perception by Escudero, the Second Language Linguistic Perception Model, or L2LP (Escudero, 2005; Mayr & Escudero, 2010), combines elements of two models, PAM and SLM. L2LP assumes the full copying stage at the first encounter of the learner with the new phonological system, when the L1 phonological system is
copied, and the duplicate is used by the learner to handle the new L2 sounds. After this copying stage, the perceptual development in L2 follows one of the two scenarios. Under the New Scenario, listeners either create a new L2 category or split the category existing in L1 to correspond to two categories in L2. Under the Similar Scenario, listeners reuse the existing L1 categories. They may still need to shift the L1 perceptual boundary to the L2 setting. L2LP places emphasis on individual variation in perceptual learning and connects the acquisitional trajectory to learners’ L1 accent that includes regional, social, and idiosyncratic features. The features of the L1 accent define the initial categorization pattern of L2 sounds as a new category, a split, or an existing category.

In summary, the models of L2 sound acquisition briefly reviewed above all focus on perception and explore the notion of the phonological sieve introduced by Polivanov in the 1930s and the mechanisms underlying perceptual equivalence of L1 and L2 phones (Polivanov, 1931). Together, they address the lower end of phonological processing, i.e., the creation of L2 phonetic categories that constitute the perceptual basis for abstract phonemes. The studies carried out in support of each of the models use sound segments that are not meaningful lexical units in L2. This is often done for methodological reasons: lexically driven factors, such as word frequency, can create response biases. At the same time, this has generated a situation when research in support of the models targeting L2 phonological perception, in fact, explores lower-level phonetic processing outside of lexical access. At the same time, these earlier models and the empirical studies supporting them have set the ground for the new research direction. Indeed, phonetic categorization is the foundation for the development of phonological contrasts.

7.2.2 L2 phonological contrasts in lexical access

A new interest in the role of phonology in lexical access and acquisition is evolving in two directions (Darcy et al., 2012; Escudero, Hayes-Harb, & Mitterer, 2008). The first direction is a continuation of the ‘phonological sieve’ tradition, in other words, the research supporting the models of phonetic categorization of L2 sounds. However, the major difference is that the focus now is on the mechanisms at work at the phonetic-lexical interface. This type of investigation is done in two ways: by exploring the influence of L2 difficulties with phonological contrasts on lexical access of existing and familiar words, or by staging a learning experiment when

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1 This chapter consistently makes a distinction between phonetic perception that deals with phonetic features and contrasts, and phonological perception that targets phonemes, minimal linguistic units potentially associated with meaning. Phonemes are language specific and are the building blocks for morphemes and words. While phonetic perception can be observed in naïve listeners, phonological perception can only be observed in L2 learners who are familiar with some words in their L2.
L2 learners learn new vocabulary with manipulated phonological properties in highly controlled experimental conditions (Escudero et al., 2008).

The second direction concerns itself with a different challenge presented by L2 lexical acquisition and access, namely, the ability to represent, store, and retrieve a lexical entry as a sequence of phonemes associated with a meaning(s) (see Eulitz & Lahiri, 2004). When L2 learners integrate L2 words into their mental lexicon, these words do not have strong phonological representations, which results in weak and uncertain mappings among similarly sounding words and their meanings (Cook, 2012). For example, *lisp* and *limp*, which differ only by one phoneme, may be weakly linked to their respective meanings, and as a result, an L2 learner may be unsure which phonological form corresponds to which meaning.

An L2 learner hears new words of a second language and needs to store them in the mental lexicon, access them, and retrieve them. In order to accomplish this task, L2 learners (and L1 speakers as well) need to convert auditory input into lexical representations. There are two extreme points of view on how this is done. The first, the episodic model, assumes a direct mapping of the acoustic signal onto the lexical representation. Thus, there is an acoustically rich trace of all the encounters with the word associated with its lexical representation stored in the mental lexicon (Bybee, 2001; Goldinger, 1998; Pierrehumbert, 2001). According to this approach, no abstract phonological level of representation is needed. Conversely, according to the abstractionist approach, acoustic input is processed pre-lexically and converted into phonological representations associated with lexical representations. Thus, all the detailed phonetic information is removed at the abstract phonological stage (Norris, McQueen, & Cutler, 2000). We will follow the position expressed in a hybrid abstractionist–episodic model that claims that pre-lexical phonological representations are abstract, and at the same time flexible and phonetically attuned. This position is explored in an L1 training study involving Dutch [f]-final and [s]-final words and words with a manipulated word-final consonant that could be interpreted as either [f] or [s] (McQueen, Cutler, & Norris, 2006). In the training stage, participants, L1 speakers of Dutch, who performed a lexical decision task (LDT), were biased to interpret the ambiguous word-final consonant as [f] or [s] depending on the word itself and the other words on the list. They were subsequently tested in a cross-modal priming LDT on new words with the same word-final ambiguous and unambiguous consonants. The biases developed in lexical access during the training stage were carried over to new lexical items, which excludes a mechanism purely based on episodic representations and requires an abstract phonological level that is associated with perceptual retuning. The study

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2 According to a recent proposal, learning phonological categories is a single-stage process that does not make use of the lexic (Dillon, Dunbar, & Idsardi, 2013). The model uses acoustic data on Inuktitut in simulations.
interprets the demonstrated perceptual retuning as an analogy of adjustments made in listening to idiosyncratic pronunciations of different talkers (including accented nonnative speech). However, it also provides evidence that acoustic/phonetic information in auditorily perceived words is processed by skilled listeners in a “linguistic mode.” Phonetic cues are associated with allophones of the same phoneme or with different phonemes, as appropriate, based on an implicit system of language-specific rules that work at the phonetics–phonology interface. We will return to allophonic variation in a subsection below.

7.2.3 L2 phonetic categorization and lexical representation: what comes first?

Given that L2 learners may experience problems at several levels involved in the phonological encoding of L2 words, it comes as no surprise that there is no equivalence between their performance on lower-level phonetic categorization tasks and higher-level processing of phonological contrasts in lexical access. However, different studies do not agree on the direction of the difficulties. Darcy and colleagues refer to these two opposite points of view as the ‘categories first’ and ‘lexicon first’ positions (Darcy et al., 2012).

The more plausible and widely accepted view is the ‘categories first’ view: that learners need to establish robust phonetic L2 categories before creating lexical representations (Darcy et al., 2012). A series of studies on Spanish–Catalan bilinguals explicitly formulated and explored this view (for a review, see Sebastián-Gallés & Díaz, 2012). The ‘categories first’ position draws on the understanding of speech perception as a hierarchically organized set of processes (e.g., Poeppel, Idsardi, & van Wassenhove, 2008) starting with lower-level acoustic input that is analyzed to derive phonetic features, then going on to convert the output of the phonetic analysis into phonological representations, and finally, matching the sequence of phonemes with a lexical representation. If this hierarchical structure is translated into the degree of difficulty in L2 phonological perception, then the higher the processing level, the less successful L2 learners are expected to be. This pattern seems to emerge from the studies conducted and reviewed by Sebastián-Gallés and Díaz that used tasks ranging from lower-level categorization to lexical decision and quantified the percent of Spanish-dominant bilinguals who handled the Catalan /e/-/ɛ/ phonological contrast within the range of native speakers. In the identification task with a continuum of seven synthesized vowels in an earlier study, 60 percent of Spanish-dominant bilinguals fell within the range of Catalan native speakers (Pallier, Bosch, & Sebastián-Gallés, 1997). In the ‘matching-gating’ task, 25 percent of Spanish–Catalan bilinguals matched the native performance (Sebastián-Gallés & Soto-Faraco, 1999). In this modification of the gating task, participants listened to minimal pairs of
nonwords differing by the Catalan /e/-/ɛ/ contrast and presented multiple times, in short increments, or ‘gates’. They chose from these two alternatives of nonword stimuli from the first gate. Their performance was assessed based on the length of the nonword (the number of gates) required for a correct decision. Finally, only 18 percent of Spanish–Catalan bilinguals performed within the native range in a LDT when judging Catalan nonwords created by switching the /e/ or /ɛ/ vowels (Sebastián-Gallés, Echeverria, & Bosch, 2005). Note that, strictly speaking, the ‘matching-gating’ task and LDT employed in the two above-mentioned studies posed different problems for the bilinguals. The ‘matching-gating’ task challenges listeners to categorize the segment based on incomplete phonetic information. It expects expert listeners to make efficient use of the properties of the short auditory segment that define or predict the vowel quality. In the LDT with nonwords created by switching the /e/ or /ɛ/ vowels, the task of the listener is to detect the mismatch in phonetic quality.

Additionally, in the often-cited medium range priming study by Pallier and colleagues (Pallier, Colomé, & Sebastián-Gallés, 2001) that used identity pairs and minimal pairs of words differing by the vowel, /e/ or /ɛ/, Spanish-dominant bilinguals, but not Catalan-dominant bilinguals, showed spurious facilitation priming effects for minimal pairs because Spanish does not have the Catalan /e/-/ɛ/ distinction. Facilitation in Spanish-dominant bilinguals was interpreted as the result of treating the members of the minimal pair as homophones. Thus, the sequence emerging from these studies is the lack of a phonetic distinction leading to the inability to differentiate lexical representations for two separate lexical items.

Studies that show that correct L2 lexical encoding can be achieved even in the absence of robust L2 phonological discrimination support the alternative ‘lexicon first’ view (Cutler, Weber, & Otake, 2006; Escudero et al., 2008; Weber & Cutler, 2004). Any asymmetrical biases in the lexical encoding of problematic L2 phonological contrasts, as opposed to their complete neutralization, are taken as evidence against the idea that homophonous L2 lexical entries correspond to the lack of differentiation of the phonological contrasts (as done in Pallier et al., 2001). In an eye-tracking study, L1 Dutch speakers had to click on pictures corresponding to auditorily presented L2 English words with the critical condition involving the English contrast between the /æ/ and /ɛ/ phonemes in the first syllable, as in *panda* and *pencil* absent in Dutch (Weber & Cutler, 2004). There was a clear bias in the pattern of fixations, so that ‘panda’ activated ‘pencil,’ but not the other way round. This asymmetry was problematic for the homophony-based account found in the Pallier and colleagues (2001) study and required additional explanation. The asymmetry reported in the Weber and Cutler (2004) study could be due to the fact that the Dutch phoneme /e/ may be perceptually closer to the English /ɛ/ than /æ/, and therefore the Dutch L1 category serves as the perceptual anchor. However, the phonetic
categorization task conducted on the same vowel contrast showed no bias in the categorization of these two English vowels by Dutch L1 listeners (Cutler et al., 2004).

The findings by Hayes-Harb and Masuda (2008) represent a somewhat different case. Following a training session, their English learners of L2 Japanese were able to reliably match the pictures with the nonword ‘brand names’ that they were given during the training. The targeted contrast was Japanese phonological geminates, /tt/ vs. /t/, absent in English. At the same time, they failed to produce the contrast in picture naming. This discrepancy should be interpreted as a manifestation of the asymmetry between L2 perception and production rather than an argument in favor of the lexical encoding of Japanese geminates in the absence of robust phonetic categorization. Also, the auditory templates for the L2 words used in the training session could serve as episodic representations rather than phonological. This effect could be similar to having robust L2 lexical representations for highly frequent words, without being able to handle all the phonetic cues to the phonemes constituting the word in all the phonetic environments occurring in other words.

A recent study reported an asymmetry in the relationship between categorization and lexical representation of a phonological contrast. The study compared the outcomes of two tasks, lower-level phonetic processing in an AXB discrimination task that used consonant–vowel–consonant (CVC) nonwords, and a lexical decision task (LDT) that used real and nonce words with the same contrasts in a repetition priming design (Darcy et al., 2012). Two groups of American learners of French, at the intermediate and advanced levels, were tested on two sets of front/back rounded vowel contrasts, high /y/–/u/ and mid /œ/–/ɔ/, notoriously difficult for English-speaking learners of French. The study calls the obtained results “a curious anomaly for standard assumptions according to which the development of new categories is a necessary prerequisite for lexical contrast” (p. 28), since although it displays a pattern of dissociation between the outcomes of two tasks for the two contrasts in question, the direction is flipped between the tasks. Indeed, the advanced learners had robust lexical representations for the lexical items testing all the contrasts in LDT; however, they showed persistent errors in the AXB task testing phonetic categorization. Intermediate L2 French learners showed spurious homophony for the /y/–/u/ contrast, but not the /œ/–/ɔ/ contrast in the repetition priming LDT; however, they observed the opposite hierarchy of difficulty for these contrasts in AXB, with the average error rate of 37 percent for the /œ/–/ɔ/ contrast, and only 15 percent for the /y/–/u/ contrast. The similarity in the results of AXB task

3 The study tests its own novel approach, ‘direct mapping from acoustics to phonology’ (DMAP), that explores the application of phonological theory to L2 lexical encoding of difficult phonological contrasts. The proposed model will largely remain outside the scope of this review.
for both groups with a significant difference in the LDT task, points to a
dissociation between phonetic categorization and lexical encoding
instead of a causal relationship between them. The authors argue that
the frequency of the lexical items used in the materials, their familiarity,
or their orthographic and acoustic properties, did not cause the observed
asymmetries. A possibility still remains that the lexical items were inte-
grated into the mental lexicons of L2 participants to different degrees,
given that the frequencies were balanced across the high/mid pairs, but
not within the front/back pairs, which is crucial for avoiding lexical
biases. If, hypothetically, the /œ/ items had higher frequency than the
/ɔ/ items, this could explain their more robust lexical representation.
Similarly, the average familiarity score was 61 percent for the /y/-/u/
pair and 85 percent for the /œ/-/s/ pair (p. 22), which points to the
possibility that the items in the mid condition were subjectively more
familiar to the participants. These two factors taken together could
account for better lexical entrenchment of the words with the mid
front rounded /œ/ than those with the high /y/. Differences in the level
of entrenchment could signify more or less robust phonological repre-
sentations of the lexical items (Diependaele et al., 2013). Given that
there were only five words representing each vowel, lexical biases
could be significant. On the other hand, an important outcome of the
study is the fact that the intermediate group’s categorization in AXB was
affected by the allophonic variation; they were more accurate in the
labial context for both contrasts.

The study by Darcy and colleagues (2012) suggests that dissociations in
categorization and lexical representation are in fact possible and to be
expected since lexical items are more or less entrenched in L2 mental
lexicons dependent on the level of L2 proficiency, while at the same time
different contextual and positional allophones of L2 phonemes may pre-
sent different perceptual difficulties according to the hierarchy of diffi-
culty. This ultimately means that while the ‘categories first’ position
corresponds better to the hierarchical view of linguistic processing, both
positions may find support in the experimental data precisely because
phonological and lexical acquisition proceed in parallel in a bootstrapping
fashion, both in L1 and L2. Depending on whether the study uses more or
less frequent lexical items, and the positional allophones occurring in the
stimuli happen to be more or less perceptually salient, the outcomes of a
particular study may favor either the ‘categories first’ or the ‘lexicon first’
view. The issue of allophonic variation as it pertains to lexical access will
be addressed below.

The lexical-quality hypothesis developed by Perfetti for reading, but also adaptable for listening "claims that variation in
the quality of word representations has consequences for reading skill, including comprehension. High lexical quality
includes well-specified and partly redundant representations of form (orthography and phonology) and flexible
representations of meaning, allowing for rapid and reliable meaning retrieval. Low-quality representations lead to
specific word-related problems in comprehension" (Perfetti, 2007: 357).
7.2.4 Orthography in L2 auditory lexical access

The possible influence of both L1 and L2 orthography on the coding of lexical representations in L2 has received attention in recent years as well (Cutler et al., 2006; Escudero et al., 2008; Escudero & Wanrooij, 2010; Hayes-Harb, Nicol, & Barker, 2010; Ota et al., 2009; Showalter & Hayes-Harb, 2013; Veivo & Järvički, 2013; Weber & Cutler, 2004). Orthography is treated as the code used in visual access of lexical representations, but also as explicit information that raises metalinguistic awareness (Escudero et al., 2008). Its supporting role in learning new phonological features is tested not only for conventional grapheme-phoneme correspondences, but also for the tone marks in the learning of Mandarin lexical tones by English L1 speakers with no prior knowledge of Mandarin (Showalter & Hayes-Harb, 2013).

The study by Weber and Cutler (2004) discussed above suggested the possibility of an orthography-based explanation for the observed bias in their eye-tracking experiment. It is possible that the different orthographic coding of the members of the contrast in English with letters a and e supports the differentiation of the two phonemes, with the letters mapping onto different phonemes in Dutch. However, the /æ/ phoneme as in panda is orthographically coded as a low back vowel in Dutch, which is inconsistent with its phonetic nature, being a low front vowel in English. Another eye-tracking study with Japanese learners of English and the notoriously difficult /ɾ/-/l/ consonantal contrast, was designed to test the two alternative explanations of asymmetric mapping of the contrast to L2 lexical representations (Cutler et al., 2006). The obtained bias was in the direction of the preference for the /l/-initial targets over the /ɾ/-initial ones, so that instructions to click on a picture of a rocket induced fixations on the picture of a locker, but not the other way round. This asymmetry speaks in favor of the role of phonetic proximity between the Japanese corresponding phoneme /ɾ/ and the English /l/, and not in favor of the orthographically-based explanation, with the Japanese romanji spelling system using the letter r for such segments. Note that both studies consider the possible influence of L1 orthography on the biases in L2 lexical representations, and not the L2 graphic-phonological correspondences that could serve as metalinguistic perceptual anchors in the process of lexical encoding of new words.

A learning study was designed to directly address the role of L2 orthography in encoding L2 lexical representations as opposed to discussing it post hoc, as was done in the studies discussed above (Escudero et al., 2008). L1 speakers of Dutch learned nonword names of non-objects in English, their L2, and were later tested on picture-word matching using eye-tracking. The words contained the /ɛ/ – /æ/ contrast confusable for

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* See the special issue 53(3) of Language and Speech, 2010, devoted to the relation between orthography and phonology from a psycholinguistic and SLA perspective.
Dutch speakers. Crucially, two groups of participants received different input in the training session, one group only auditory names of non-objects, and the other both auditory and visual spellings. Accordingly, only the first group trained solely on the auditory input showed a symmetrical pattern of confusions with fixations on pictures representing both phonemes in response to both. The second group that received additional orthographic input was biased to look at both /ɛ/-word and /æ/-word pictures in response to /æ/-words, but only to /ɛ/-word pictures in response to /ɛ/-words. Given that the vowel letters ‘a’ and ‘e’ chosen to represent the contrast orthographically are the same that are used by the English spelling system, the study demonstrates the role of orthography in shaping (and biasing) lexical representations with confusable L2 phonemes.

Thus, orthography contributes to consolidating L2 phonological representations if it is consistent with the expected phonetic–orthographic mappings. When the phoneme–grapheme mappings are inconsistent with the orthographic system of L1 or L2, orthography cannot help to consolidate the new lexical representations (e.g., the letter ‘a’ is expected to correspond to a back, and not front English vowel based on Dutch orthography). Remarkably, phonological confusions in L2 also lead to orthographic confusions and spurious homonymy, as was shown in a visual study using the /r/–/l/ contrast in a semantic relatedness task with Japanese learners of English (Ota et al., 2009). The participants judged the semantic relatedness of the pairs such as LOCK/HARD and ROCK/KEY to be higher than that of the controls. Thus, lexical representations of the minimal pairs of words differing by a difficult L2 phonological contrast are not well separated in the mental lexicon. As we will see below, this fuzziness of L2 lexical representations may go beyond the confusable L2 phonological contrasts and lead to uncertainty about any potentially confusable word segments, as in word neighborhoods.

7.2.5 Allophonic variation

The previous sections have discussed the processing of nonnative phonetic input with the goal of forming easily retrievable lexical representations of L2 words. This process is hypothesized to hinge on the development of L2 phonological representations that serve as the coding units for lexical representations. The difficulties experienced by L2 learners have to do with the need to attune the phonetic categories to L2 input and to reassemble the distinctive features into new L2 feature matrices corresponding to the phonological system of L2 (see Darcy et al., 2012). In doing so, they will need to overcome the categorization routines deployed in L1. As the study by Darcy and colleagues shows, there is a certain dissociation between the establishment of robust L2 phonetic categories and lexical representations.
At the lexical representations’ end, the level of entrenchment depends on word frequency in the input and its familiarity. At the phonetic categorization end, perceptual correlates of different allophones of the same phoneme, that depend on the phonetic environment (adjacent sounds) and phonetic position (e.g., position in the word, or in relation to lexical stress), have different perceptual salience. Therefore, in order to establish robust phonological units (phonemes), the learner needs to develop phonetic correlates of the unit that are connected to the unit through a system of allophonic variation rules. Perceptual salience is often defined by universal constraints on production and perception, e.g., articulatory weakening of the word coda may lead to final consonant devoicing in some languages.

Allophonic variation has been documented in studies focusing on phonetic categorization (Darcy et al., 2012; Levy, 2009; Lukyanchenko & Gor, 2011; Shea & Curtin, 2010). Levy (2009) reported the influence of the consonantal context on perceptual assimilation of French vowels by naïve American listeners and American learners of French. The study by Darcy and colleagues (2012) observed a perceptual facilitation in the categorization of French front rounded vowels when the labial context was conducive to a better discrimination of the front/back rounded vowel contrast.

Lukyanchenko and Gor (2011) explored a phonological contrast that is heavily functionally loaded in the Russian consonantal system, and is present in a large set of consonant allophones. Their study investigated the acquisition of the distinctive feature (DF) of softness (opposed to hardness) in Russian consonants by early (heritage) and late L2 learners, native speakers of American English. It demonstrated that the DF of softness that has different articulatory and acoustic correlates for different consonants depending on their place of articulation, is acquired not “all or nothing,” but rather occurs in piecemeal fashion, with contextual and positional allophones acquired in a sequence determined by their robustness in terms of containing interpretable acoustic information. While native speakers are able to interpret subtle phonetic cues to the hard/soft feature and perform at ceiling, L2 learners seem to be able to handle only the more salient phonetic cues.

Shea and Curtin have reported a gradually developing L2 ability in intermediate learners of Spanish, L1 English speakers, to connect the allophones of voiced consonants in Spanish with the position in relation to word onset and stress, and to link stops to stressed word onsets and approximants to unstressed word-medial position (Shea & Curtin, 2010). Their finding supports the idea that native speakers develop the ability to pay attention to the relevant perceptual information in the acoustic wave

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6 Note that both a more detailed and a more global Gestalt lexical representation are the possible outcomes of greater entrenchment.
and ignore the irrelevant information, an ability lacking in L2 learners who are not attuned to the L2 phonetic contrast.\(^7\)

These studies show how the differences in the strength of perceptual cues in contextual and positional allophones affect L2 processing of phonological contrasts, while native speakers are performing at ceiling. They stop short of addressing the issue of lexical representations, since they work with nonword materials; however, they demonstrate that at the low end of the phonetics–phonology interface, the robustness of a phonological representation depends on the robustness of perceptual cues to all its contextual and positional allophones. The differences in the strength of perceptual cues provide a reasonable explanation for the “anomaly or paradox” of the findings of Darcy and colleagues (2012). Lexical representations for very high-frequency lexical items may be more robust than the representation of the phoneme itself, when it gets to all its possible perceptual correlates in different allophones.

### 7.2.6 Individual variation and L2 proficiency

The variation observed in individual acquisitional paths has received increasing attention in the context of L2 phonological coding of lexical representations (Díaz et al., 2012; Mayr & Escudero, 2010; Sebastián-Gallés & Díaz, 2012). Since L2 linguistic performance is typically characterized as highly variable, both within and across individual learners, the data on individual variability in L2 phonology fit well with general L2 acquisitional patterns and present no exception to variation witnessed in other domains. The L2LP model (Escudero, 2005; Mayr & Escudero, 2010), as discussed above, states that L2 phonological perception is strongly influenced by the L1 accent, which includes the regional, social, and individual features of the L2 learner. The claim about individual variation in L2 perceptual patterns was confirmed by a study of German vowel perception in L1 English listeners (Mayr & Escudero, 2010).

In a study by Díaz and colleagues, L2 learners, late Dutch–English bilinguals, have shown more individual variation in lower-level phonetic categorization than higher-level phonological identification and especially in lexical decision performance in processing the difficult /æ/ – /ɛ/ contrast (Díaz et al., 2012). Sebastián-Gallés and Díaz (2012) review several behavioral and neurolinguistic studies that additionally point to a crucial relationship between L1 and L2 perception capacities, a dimension often overlooked in L2 perceptual studies.

\(^7\) This chapter advocates the position that the information about the adjacent phonetic segments and the position of the segments in the word and the sentence is relevant, and needs to be part of the phonological representation of the word. However, according to a more restrictive view, only the information supporting the contrastive features is represented in the brain (see Eulitz et al., 2004).
While some aspects of individual variation are more idiosyncratic and involve L1 and L2 regional dialects in contact, others are more systematic in that they reflect a general developmental trend associated with the differences in L2 proficiency (Darcy et al., 2012; Lukyanchenko & Gor, 2011; Shea & Curtin, 2010; Veivo & Järvikivi, 2013). As predicted, the studies that compare late L2 learners at different proficiency levels document a developmental tendency in phonetic categorization of nonnative L2 phones. The improvement evidenced in perceptual performance is shown to depend on increased efficiency in the processing of the less salient perceptual cues in the most difficult allophones (Lukyanchenko & Gor, 2011) and allophonic distributions determined by the phonetic position, both in perception and production (Shea & Curtin, 2010). One can expect that the level of entrenchment of lexical representations will also depend on its frequency in the input, and ultimately, on the amount of exposure and the L2 proficiency level, given the findings on the fuzziness of lexical representations discussed below.

### 7.2.7 Phonological encoding of L2 lexical representations

This section will review the studies focusing on phonological encoding in L2 lexical access. They seek to explain the mechanisms of lexical activation leading to spurious priming effects involving minimal pairs of L2 words, as well as words and nonwords (Broersma, 2009; Broersma & Cutler, 2008). This line of inquiry leads to a more puzzling and less researched aspect of nonnative lexical access, when the form–meaning mappings of the lexical entries that have similar phonological representations are insufficiently robust, which leads to spurious effects in L2 lexical access (Cook, 2012; Gor, Cook, & Jackson, 2010).

A series of cross-modal priming studies has demonstrated facilitation in L2, but not L1 participants (Broersma, 2009; Broersma & Cutler, 2008). Dutch learners of English showed facilitation for near-words that constituted minimal pairs with real words and differed by the voicing of the final consonant, as in *groof–GROOVE* (Broersma & Cutler, 2008), a phenomenon that the authors called “phantom word activation.” In another cross-modal experiment, *flash* primed *FLESH* and *robe* primed *ROPE* in some Dutch learners, but caused inhibition in other Dutch learners and native speakers of English, following the predictions based on the perceptual problems with the /æ/–/ɛ/ contrast and the final consonant voicing contrast in Dutch L2 learners of English (Broersma, 2009). The proposed explanation is spurious activation of the lexical representations of phonological neighbors when the phonological contrast is not robust in L2 learners. In other words, the prime *flash* activates *flash* and also its neighbor *flesh*, and in L2 learners, the absence of competition among the activated neighbors produces facilitation. Also left open is the possibility that the lack of the phonological contrast that differentiates the two words leads to the
creation of two homophones that do not compete with each other in the absence of any disambiguating context.

The phenomenon of facilitation in L2 phonological priming was confirmed in an auditory priming experiment involving Russian words with an initial three-phoneme overlap as in /vrak/ enemy – /vraʧ/ doctor, and American learners of Russian as participants. While native Russian controls showed the expected inhibition, L2 learners showed facilitation (Gor, Cook, & Jackson, 2010). A study that proposed the Second Language Lexical Access Model (SLLAM) tested the hypothesis that L2 learners have fuzzy lexical representations due to underspecified phonological encoding of the word forms, resulting in less than robust form–meaning mappings (Cook, 2012). This hypothesized feature of L2 lexical representations leads to two consequences predicted by the author. First, in a phonological priming experiment, L2 listeners show pre-lexical facilitation because they are not ready to commit themselves to the selection of one competitor, and the cohort neighborhood activated by the prime facilitates access to the target. Second, a pseudo-semantic priming experiment was designed to explore the puzzling finding of L2 phonological facilitation in the absence of phonological difficulty (Cook, 2012). It used the following logic: if L2 learners do not have robust phonological representations of lexical entries, they may be uncertain about the form–meaning mappings of the words that they confuse. As a result, a semantically unrelated target could be interpreted as its neighbor that is semantically related to the prime. If this is the case, L2 learners should show the priming effects for such unrelated trials with potentially phonologically confusable targets, while native speakers would ignore any neighbors in a pseudo-semantic priming task. In the experiment, the word pair корова–молоко /karova/ – /malako/, Eng. ‘cow’–‘milk’ is presented in the true semantic condition, while the pair корова–молоток /karova/ – /malatok/, Eng. ‘cow’–‘hammer,’ with /malatok/ ‘hammer’ phonologically confusable with /malako/ ‘milk,’ is presented instead of a true semantically related pair in the pseudo-semantic condition. The participants, American learners of Russian at two proficiency levels, intermediate and advanced, as well as a control group of Russian native speakers heard only one pair depending on the presentation list. Neither NSs of Russian nor intermediate L2 learners were sensitive to pseudo-semantic primes. However, advanced L2 learners showed inhibition in the pseudo-semantic condition for high-frequency items. This effect is attributed to underspecification of phonological representations of words that leads to the competition with the semantically congruent phonologically confusable word (when milk is expected after cow, hammer is accessed more slowly). Thus, phonological encoding of L2 lexical representations may be unfaithful even in the absence of a perceptually difficult phoneme.
7.2.8 Summary
This section on the processing of L2 phonology has reviewed the models, theories, and empirical research focusing on both sides of the phonetics–phonology interface and the interaction of bottom-up and top-down processing. L2 phonological categories emerge in a bootstrapping fashion through perceptual training and vocabulary learning. In late L2 phonological acquisition, learners need to learn how to handle several auditory processing stages in order to efficiently encode, store, and access lexical units. These stages include auditory processing that is largely unaffected by the specific language or languages in contact, but also phonetic cue extraction that is language specific, association of phonetic cues with phonetic allophones through the rules that make adjustments for the phonetic position and context, encoding of the auditory input as a sequence of phonemes, and access of the lexical representation(s) that match the phonological sequence. All these stages are not linearly sequenced, but rather overlap, or are activated in a parallel or cascaded manner (and also affected by top-down processing depending on the use of the semantic cues, sentence context and beyond, etc.). On the phonetic side of the interface, L2 phonetic cue extraction plays a crucial role. On the phonological side of the interface, lexical frequency and ultimately the role of L2 input determine the robustness of L2 phonological representations of lexical units containing the contrast. The important consequence is that phonology in L2 lexical access can ‘break’ at any stage, and thus L2 learner faces multiple challenges, with a failure at each level having consequences for other levels. Thus, for example, if one is confused about the phonological make-up of a stored word, one risks retrieving its phonological neighbor instead. However, if one does not have a robust system of rules for handling the cues for phonetic allophones, one can erroneously misinterpret a phonetic segment as an allophone of a different phoneme, which may lead to the same outcome – retrieval of an incorrect word.

7.3 Processing of L2 morphology
Efficient phonological encoding discussed above is a crucial part of creating robust form-meaning mappings that L2 learners need for word storage and retrieval from the mental lexicon. However, words may have complex internal structure, i.e., comprise two or more morphemes, minimal linguistic units carrying lexical or grammatical meaning. The main issue in research on morphological aspects of L2 lexical access is whether L2 learners decompose morphologically complex words or if they retrieve them as whole words, by relying only on phonological form–meaning mappings. While this issue concerns inflectional and derivational morphology alike, there are indications in the literature that L2 learners master English inflection before derivation (e.g., Gardner, 2007), and it is
still an open question whether the sequence remains the same for languages with a rich inflectional system and many inflectional morphemes (and their exponents, or surface phonological forms) to be internalized. Inflectional and derivational morphology have distinct linguistic functions; inflection subserves morphosyntax, e.g., the English -ed morpheme signals that the verb is in the past tense, and derivation contributes to the creation of new words by adding derivational morphemes and often changing the word class, e.g., adding the morpheme -er with the general meaning ‘doer of the action named by the verb’ to the verb read creates the noun read-er. It is believed that both inflection and derivation are processed by the same decompositional mechanisms (see Diependaele et al., 2011). At the same time, functional magnetic resonance imaging (fMRI) evidence on brains localization of auditory processing of inflection and derivation indicates that in English, inflection is indeed processed by the left-lateralized decompositional system, while derivation is processed by a widely distributed bilateral system that is also involved in the processing of monomorphemic words (Bozic et al., 2010). A combined electroencephalography (EEG) and magnetoencephalography (MEG) study of Finnish inflection and derivation using an acceptability judgment task came to similar conclusions, that while inflected words are processed by decomposition, derived words may be initially processed as whole words as well as through constituents (Leminen et al., 2011). One possibility is that complex derived words are stored in the mental lexicon both as whole words and constituents, while inflected words may or may not have whole-word representations at the lemma level depending on their surface frequency, and the complexity and productivity of the inflectional pattern. Another possibility is that decomposition of derived words has implications for lexical processing more than syntactic processing. From a linguistic standpoint, inflectional and especially derivational morphemes are involved in word-internal syntax (Marantz, 2013). The following subsections discuss research on L2 inflection and derivation separately, while acknowledging that both create potentially decomposable morphologically complex words.

7.3.1 Processing of L2 derived words
The processing of derivation in lexical access has been studied in masked priming experiments when the prime is visually presented for a very short time, around 50 ms, after a mask (often, a line of hash marks), and then immediately followed by a visual target. The effects observed in L1 speakers point to more than one underlying processing mechanism involved in early visual processing of derivational morphology (for a review, see Diependaele et al., 2011). Native speakers of English are sensitive to morphological structure in both transparent (e.g., singer–SING) and opaque (department–DEPART) derivations, and even pseudo-derived words, such
as *corner-CORN* (Rastle & Davis, 2008). Such early automatic morpho-orthographic decomposition appeared to be blind to semantic properties or the actual morphological structure, with *corner* facilitating responses to *CORN*, as long as the word contained a phonological segment corresponding to an existent derivational suffix. However, the situation is complicated by a graded facilitatory effect observed in English speakers, with a greater facilitation for semantically transparent (*viewer–VIEW*) than opaque (*department–DEPART*) derivations (Diependaele et al., 2011). This graded effect suggests that native speakers are sensitive to semantic properties of derived words very early on in the time course of lexical access. Both effects can be accommodated within the cascaded approach with morpho-orthographic and morpho-semantic processing starting early and overlapping in time.

The predictions regarding the differences between L1 and L2 processing of derivational morphology in lexical access tasks, such as the masked priming task, range from the position that the L1 and L2 mechanisms are different, albeit less so than the ones responsible for inflection (Clahsen et al., 2010; Kirici & Clahsen, 2012), to the claim that they are the same (Diependaele et al., 2011). Diependaele and colleagues (2011) replicated the findings on the significant graded effect of transparent and opaque derivation in a masked priming study comparing two groups of L2 learners of English with Dutch and Spanish as L1 with native speakers of English. They confirmed that L2 learners relied both on early morpho-orthographic decomposition (hence the masked priming effects) and that the magnitude of facilitation was mediated by semantic transparency (hence the graded-ness of the effect). The two L2 groups had similar, though not identical learning profiles, including self-assessed measures of proficiency. The results were taken as support of the same processing strategies in L2 and L1 speakers, and the reality of early morpho-semantic transparency effects.

Early morpho-orthographic effects were likewise demonstrated in a masked priming study involving a group of advanced L2 learners of English with L1 Spanish, and a group of balanced early Basque–Spanish bilinguals (Duñabeitia et al., 2013). The main focus of the study was to establish that morpho-orthographic decomposition did not crucially depend on the translation of the prime in the mixed-language condition when the prime and the target belonged to different languages. This was done by carefully manipulating the cognate status and the adjusted Levenshtein distance (the degree of orthographic overlap) between the prime and the target. The study does not report significant differences between the unbalanced (L2) and balanced (bilingual) groups. Given that the “weaker” Spanish–English group included highly proficient English learners, both groups could have been at ceiling in their L2.

A different pattern of results was reported in a study of English deadjectival nominalizations using the suffixes *-ness* and *-ity* in a series of LDT
and masked priming experiments with native speakers and L2 learners of English, whose L1 was Chinese and German (Clahsen et al., 2010; Silva & Clahsen, 2008). Their English L1 participants showed full priming, but two groups of L2 learners only partial priming for the derived words. The weakening of the priming effect in L2 participants was taken as evidence in support of Ullman’s (2001, 2012) declarative/procedural model, according to which combinatorial structure affects L2 processing less. Remarkably, there was no significant difference between the two learner groups despite the fact that Chinese is an inflectionally poor language and has ideographic script, while German is typologically close to English, both being Germanic languages.

Diependaele and colleagues (2011) compared the two datasets, their own and the one from the Silva and Clahsen study (2008), to identify the loci of the differences. Several possibilities emerge, including differences in L2 proficiency, with the participants in Silva and Clahsen (2008) having lower proficiency than those in their study. Other potential reasons include the differences in L1 background, a limited set of only two derivational suffixes, and few items per condition in the study by Silva and Clahsen (2008). Given that the study of Silva and Clahsen (2008) reports partial priming for derived words, and not complete absence of priming, and also given some of their methodological choices listed above (i.e., their participants are not highly proficient L2 learners, and they include Chinese L1 speakers), it appears that a strong non-decompositional account for L2 does not find conclusive experimental support. Conversely, the studies by Diependaele and colleagues (2011), and Duñabeitia and colleagues (2013) show robust decomposition of semantically transparent derivations and a graded effect depending on semantic transparency with highly proficient L2 learners. These two datasets suggest a developmental tendency whereby L2 learners gradually learn to quickly and efficiently decompose words with derivational affixes. In other words, L2 learners do not rely on a categorically different processing mechanism of whole-word lexical access as postulated by the declarative/procedural model (Ullman, 2001, 2012), but gradually develop sensitivity to morphological structure of derived words. A somewhat different pattern of results was observed in a masked priming study in L2 Turkish, an agglutinative language that extensively uses affixes, comparing the facilitation patterns for inflection and derivation (Kirici & Clahsen, 2013). While L1 speakers of Turkish showed facilitation both for inflection and derivation, L2 learners showed facilitation only for derivation, but not for inflection. These results led the authors to conclude that the differences in L1 and L2 processing of morphologically complex words are subtle rather than superficial or obvious. Overall, the reviewed studies converge on the fact that L2 learners decompose derived words in lexical access, albeit showing less facilitation than native speakers.
7.3.2 Do L2 learners decompose inflected words?

Similar to the debates surrounding morphological decomposition in a native language that started with English regular and irregular past-tense inflection, the research on L2 morphological processing initially focused on English past-tense verbs and later turned to morphologically rich languages with a developed inflectional paradigm (see Gor, 2010). L2 decomposition of inflectional morphology has generated two opposite points of view (for a review, see Gor & Jackson, 2013). According to the non-decompositional account, L2 learners do not decompose inflected words, but instead store and retrieve whole-word representations instead (Babcock et al., 2012; Clahsen & Felser, 2006; Clahsen et al., 2010; Ullman, 2001, 2012). Proponents of this view see the developmental trajectory in L2 acquisition of inflection as the initial reliance on whole-word storage that persists and only gives way to decomposition at advanced proficiency levels. With regard to the impact of regularity on L2 morphological decomposition, this view supports the dual-system approach and claims that while native speakers decompose regularly inflected words and store irregularly inflected ones, L2 learners store both types of words. From English as a native language, the agenda soon expanded to include a range of typologically different languages as L1 and L2 in nonnative and early bilingual populations.

The studies supporting the non-decompositional view of L2 inflectional morphology use a range of tasks, including oral and written verb generation, auditory and visual lexical decision tasks, priming experiments with a visual, auditory, and cross-modal presentation, and short to medium lag, and masked priming. Data collected include behavioral measures, accuracy and response latencies, as well as positron emission tomography (PET), fMRI, MEG, and EEG neural data. This short review mainly focuses on reaction time data. In a masked priming study, Polish learners and native speakers of German showed similar partial priming for German irregular -n inflected past participles, while the groups differed on regularly inflected -t participles serving as primes for first-person singular targets. Native speakers were fully primed by regular participles, but L2 learners were not primed (Clahsen et al., 2010; Neubauer & Clahsen, 2009). Clahsen and Felser interpreted these findings within the shallow-structure hypothesis postulating that L2 learners rely on whole-word access and do not decompose inflected words (Clahsen & Felser, 2006); however, it is unclear what mechanism drives selective L2 sensitivity to morphological similarity between primes and targets in irregular, but not regular inflection. Indeed, in keeping with the logic of the regular/irregular morphological processing distinction, one would expect decomposition of irregular word forms to be more effortful than that of regular forms. A partial replication of the study using the same materials, but

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8 See Smolka and colleagues (2007) for a critical analysis of the methodological issues in the study.
only the regular verb condition, and two presentation procedures, with one including a 200-ms blank between the masked prime and the target, obtained no priming in L1 Arabic speakers, L2 learners of English (Clahsen et al., 2013).

Two studies demonstrated frequency effects in the generation of both irregular and regular English past-tense verbs (Babcock et al., 2012), and Spanish present-tense verbs (Bowden et al., 2010). The dependent variable was reaction times in a production task. These findings were interpreted as support for the declarative/procedural model predicting the reliance on whole-word storage for both regular and irregular verbs in L2 learners. While the frequency effects in L2 regular and irregular verb generation are well documented, their interpretation as the proof of the lack of decomposition in L2 learners is less straightforward. The studies by Babcock and colleagues (2012) and Bowden and colleagues (2010) interpret the observed surface frequency effects as proof of whole-word storage; however, according to Baayen and colleagues, surface frequency effects are indicative of decomposition, and not whole-word storage (see Baayen, Wurm, & Aycock, 2007 for a detailed argumentation and experimental support of this interpretation). Additionally, since surface frequency often correlates with stem frequency, the frequency effects in verb generation could be driven by stem frequency, which is traditionally associated with decomposition, as well (Gor & Jackson, 2013). Indeed, a greater effect of frequency on L2 lexical processing is well-established (Diependaele, Lemhöfer, & Brysbaert, 2013). These methodological limitations open to reasonable doubt the interpretation of the findings based on the effect of surface frequency as straightforward evidence for the lack of decomposition in L2.

The opposite, decompositional account has been gaining more ground with experimental support from studies of Swedish and Russian as L2. According to the decompositional account, L2 learners of morphologically complex languages, but also English, decompose inflected words in lexical access (Basnight-Brown et al., 2007; Gor & Cook, 2010; Gor & Jackson, 2013; Portin et al., 2008; Portin, Lehtonen, & Laine, 2007). This does not imply that there are no differences in L1 and L2 morphological processing; indeed, depending on their proficiency level, L2 learners may not be very efficient at decomposition. They are also notoriously slower than native speakers on all reaction time tasks involving lexical decisions or some form of lexical access. On the other hand, it is unlikely that they can rely on whole-word storage instead of decomposition, because they do not benefit from sufficient input and practice to internalize all the inflected forms in the paradigm of a given lexical entry, especially in inflectionally rich languages. Memory constraints can also play a role in

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9 Since the reaction times measured in a production experiment also include the interpretation of the initial word form, these data speak both to the decomposition costs involved in the processing of the presented stimulus word and the composition costs involved in the generation of the required word form. This negatively affects the interpretability of RTs in production.
L2 learners if they store multiple forms of the same lexeme. An additional argument in favor of L2 decomposition is the need to interpret the grammatical information contained in the inflection for successful speech processing that makes decomposition of inflected words obligatory, even if it is done post-lexically. The developmental trajectory, beyond the initial chunk learning in novice L2 learners, is hypothesized to go from decomposition to whole-word representation of inflected words, with the high-frequency ones stored first. Crucially, this view interprets regularity as a continuum rather than a categorical parameter, and accordingly, places emphasis on the role of complex allomorphy in the efficiency of L2 decomposition (Basnight-Brown et al., 2007; Feldman et al., 2010; Gor & Cook, 2010; Gor & Jackson, 2013).

The decompositional account is supported by the research on decompositional costs incurred by L2 learners of Swedish when accessing Swedish polymorphemic words matched on a number of criteria, such as length and frequency, with monomorphemic words (Portin et al., 2007; Portin et al., 2008). According to the studies, L2 learners gradually develop whole-word representations of polymorphemic words, by starting with high-frequency polymorphemic words and later adding lower-frequency ones. These studies demonstrate the role of the L1 background, with Chinese L1 speakers lagging behind Hungarian L1 speakers in developing whole-word representations (Portin et al., 2008). Given that Chinese lacks inflectional and derivational morphology, a reduced sensitivity of Chinese L1 speakers to Swedish polymorphemic words is to be expected. Indeed, a study that investigates visual word recognition of L2 Finnish inflected nouns with transparent and semitransparent morphophonology confirms the role of L1 and typological distance between L1 and L2. Russian has a rich inflectional system, while Chinese does not make extensive use of inflectional morphology, and accordingly, the response pattern (RTs) of L1 Russian participants was similar to that of Finnish native speakers and different from Chinese L1 speakers (Vainio, Pajunen, & Huölä, 2013).

Two studies of facilitation in masked and cross-modal priming experiments targeting English past-tense regular and irregular verbs highlight the role of form similarity in visual morphological decomposition (Basnight-Brown et al., 2007; Feldman et al., 2010). The first study compared the RTs to regular, irregular nested (drawn–DRAW) and irregular stem-change verbs (ran–RUN) in L1 speakers of English, Serbian, and Chinese (Basnight-Brown et al., 2007). Crucially, the two nonnative groups were matched for proficiency. While in English speakers there were comparable priming effects for regular and irregular nested verbs, and a reduced priming effect for irregular stem-change verbs, there was no facilitation in either L2 group for irregular stem-change verbs. At the same time, Serbian participants showed facilitation for regular and irregular nested verbs, while Chinese participants showed facilitation for regular verbs only, which again supports their reduced sensitivity to
morphological structure. Thus, the study demonstrates that English regularly inflected verbs are decomposed by L2 learners regardless of the language background, while irregular verbs elicit a graded priming effect in L1 and L2 speakers. Depending on the degree of form overlap and L1 background, irregular verbs may or may not produce the priming effects in L2.10

The second study (Feldman et al., 2010) used regular and length-preserved (fell–FALL) and length-change (taught–TEACH) irregular verbs in a masked and cross-modal priming tasks. Both native English speakers and L1 Serbian learners of English produced the strongest priming effects for regular verbs. English L1 speakers also showed facilitation for irregular length-preserved verbs, while L1 Serbian speakers showed no difference between irregular verbs and their orthographically matched controls (fill–FELL). Another finding important for the understanding of L2 lexical storage and access is the lack of inhibition in the orthographic control condition in L2 learners, with significant inhibition in L1 speakers. This effect seems to point in the same direction as the data on the lack of inhibition in phonological priming reported for L2 learners of Russian (Gor et al., 2010), namely their inefficiency in L2 form processing that possibly leads to fuzzy or unfaithful L2 lexical representations.

An auditory priming study explored the graded effect of regularity treated as complexity and productivity in stem allomorphy in Russian first-person singular non-past tense primes with infinitive targets and its interaction with L2 proficiency (Gor & Jackson, 2013). Three groups of L2 Russian learners, native speakers of American English, with highly controlled proficiency levels, advanced, advanced high, and superior on the standardized test, the oral proficiency interview (OPI), and a group of Russian native speakers participated in the study. The critical conditions used three types of verbs ranging in the degree of regularity – regular, semi-regular, and irregular – balanced in lemma and surface frequency across the verb types. While robust facilitation was observed in native speakers of Russian for all three verb types at all frequency ranges, in L2 learners it was observed only for high-frequency verbs. Low-frequency verbs produced an interaction of the degree of regularity with proficiency level. Priming effects were present for regular verbs at all three proficiency levels, semi-regular verbs at two higher levels, and irregular verbs only at the highest level. The study concludes that L2 learners rely on decomposition rather than whole-word storage and access of inflected words with simple and productive stem allomorphy. With increasing L2 proficiency, they gradually learn to efficiently access complex stem allomorphs in unproductive inflected forms of low-frequency words, and thus expand the range of complex words that they decompose in lexical access.

Note that the masked priming effects have been shown for stem-change verbs as fell–FALL for native speakers of English (Crepaldi et al., 2010).
7.3.3 The inflectional paradigm in L2 processing

A new agenda emerging in L1 and L2 studies of morphological processing is the role of the inflectional paradigm in lexical access of inflected word forms. This line of research has started with the nominal paradigm in Serbian, a Slavic language with a Latin-based system of cases (Milin, et al., 2009). The information-theoretical approach applied to the Serbian paradigm has generated a measure, relative inflectional entropy, that positively correlates with reaction times (RTs) and error rates in a visual LDT. The calculations are based on the understanding that it is the deviation of the distribution of the frequencies of inflectional exponents (inflections that have the same surface form and belong to a particular paradigm) in the inflectional paradigm of a particular word from the similar distribution established for the whole inflectional class to which the word belongs that increases response latencies in word recognition. The greater the difference between the two measures of entropy, or the relative entropy, the longer latencies are to be expected. It should be noted, however, that the predictive power of this measure is weaker than that of surface frequency of the inflected word. This measure has been shown to work for single-word presentations in a LDT, and it is to be expected that it will be competing with expectancies based on phrase or sentence context when it is available.

The role of the inflectional paradigm in the processing cost incurred by L1 and L2 Russian listeners was evaluated in an auditory LDT that used Russian nouns in the nominative singular (the citation form) and the genitive (oblique) case matched in surface and lemma frequency, and in length (Gor & Lukyanchenko, 2013). Crucially, nouns in the masculine paradigm have zero overt inflections in the nominative (and also in the accusative if they are inanimate), and the inflection -а in the genitive singular. Conversely, feminine nouns have the inflection -а in the nominative and a zero (-ø) overt inflection in the genitive plural. The exponent frequency is comparable for all four exponents within each inflectional class (-а and -ø, each in the masculine and feminine paradigms). Such a design made it possible to evaluate the processing costs and to test three predictions about the speed of access for each of the four critical conditions, zavod-øMascSgNOM, zavod-aMascSgGEN (factory), bumag-aFemSgNOM, and bumag-øFemPlGEN (paper). Based on the decomposition costs, the overt -а inflection should incur an additional decomposition cost, regardless of the case. Based on case (exponent) frequency, bumag-a should be processed slower than zavod-ø, and both faster than the oblique forms. Based on case hierarchy, the nouns in the nominative case should be processed faster than the nouns in the genitive. The results obtained for L1 support the prediction based on case hierarchy, with the nouns in the nominative processed at the same speed, regardless of their inflection, overt or
zero, and faster than the nouns in the genitive. Crucially, the noun $\text{bumag-ø}_{\text{FemPlGEN}}$ (paper) showed a processing cost in L1 comparable to $\text{zavod-ø}_{\text{MascSgGEN}}$. However, intermediate to advanced L2 learners did not incur a processing cost for the zero-inflected $\text{bumag-ø}$ while they did so for $\text{zavod-ø}_{\text{MascSgGEN}}$. These results are taken as evidence of decomposition both in L1 and L2, and document the role of the case status (the nominative is represented as whole word at the lemma level), and case frequencies. However, L2 learners did not incur the decomposition cost in processing zero-inflected oblique nouns that were observed in L1 participants. Results of the study suggest that L2 learners decompose inflected words in lexical access and use the stem to access the word’s lexical meaning. Similarly to L1 speakers, L2 learners process the grammatical information encoded in the inflection. However, unlike L1 speakers, lower-proficiency L2 learners are less concerned with the outcomes of recomposition and may ignore the rechecking stage altogether under specific conditions. In this sense, they are more focused on the lexical meaning expressed by the stem than on the integration of the stem and the morphosyntactic information contained in the inflection.

7.3.4 Summary
Do L2 learners decompose morphologically complex words? The general answer is 'yes,' as it is for L1 speakers, however, it requires a set of qualifications:

- This pertains to L2 learners beyond the beginner level of proficiency, at which they tend to memorize words and phrases as unanalyzed chunks.
- Even L2 learners may have whole-word representations for high-frequency inflected words, and will use the direct access route.
- In the case when both decompositional and whole-word access routes are available to the L2 learner, the choice of the route will depend on the task.$^{11}$
- There is an interaction between L2 proficiency and complexity and productivity in stem allomorphy. The higher the L2 proficiency, the more efficient the decomposition of words with complex allomorphy.
- Decomposition of derived words is driven by semantic transparency, as in L1.
- L2 morphological decomposition is often effortful and may be unsuccessful.

$^{11}$ In processing natural input, the choice of the route will likely be influenced by the linguistic structure, in which the word is embedded. For example, case agreement in a sentence will call for decomposition and morphosyntactic interpretation of inflections, even if it is done postlexically, after the lexical meaning of the word is accessed. In psycholinguistic experiments, priming may be conducive to decomposition while LDT may be conducive to whole-word retrieval. The composition of nonwords (whether the violation is in the stem, the inflection or in their illegal combination) will also influence the access route (Taft, 2004).
Do L2 learners rely on the same mechanisms as L1 speakers in lexical access of morphologically complex words? Here, the answer ‘yes’ needs even more qualifications. It depends on what evidence will be considered as supporting qualitative differences (since quantitatively, L2 learners are obviously slower and have smaller mental lexicons, with lower subjective lexical frequencies compared to L1 speakers). It crucially depends on L2 proficiency level, since L2 learners need time to understand the morphological structure of L2 and then practice to become efficient at using L2 morphology in native-like ways. Reliance on the same processing mechanisms and successful processing are not the same thing.

7.4 Future directions: L2 phonology and morphology in lexical access

The domain of L2 phonology in lexical access has seen a new interest in the phonology/lexicon interface, both with regard to perceptually difficult L2 contrasts embedded in L2 words, and the phonological encoding of words with robust contrasts, but unfaithful lexical representations and fuzzy form-to-meaning mappings. A promising direction is word-learning experiments that introduce new vocabulary with highly controlled phonological properties (Escudero et al., 2008). These experiments obviate the problems of existing vocabulary items that are often impossible to match on phonological parameters, and have different familiarity for L2 learners. The use of highly controlled materials in vocabulary learning holds a promise in distinguishing the levels of processing difficulty encountered by L2 learners – be it phonetic categorization, attending to allophonic rules, or developing robust lexical representations with the phonological form clearly spelled out.

Researchers examining the phonological structure of L2 lexical entries and the organization of L2 mental lexicon have begun to explore an L2-specific effect, namely the lack of inhibition (observed in L1), or even facilitation in phonological priming and pseudo-semantic priming (Gor et al., 2010; Cook, 2012), and the lack of inhibition in the orthographic condition in cross-modal priming (Feldman et al., 2010). These effects are indications that L2 form representations are fuzzy, which leads to less than robust form-meaning mappings, and to confusion and lack of competition among phonologically similar L2 lexical entries. The effects are in agreement with the weaker lexical entrenchment account in L2 (Diependaele et al., 2013). Future research will elucidate the nature of the mechanisms underlying the reported form priming (phonological and orthographic). It is possible that fuzzy form–meaning mappings lead to a certain L2 processing mode when the L2 learners ‘procrastinate’ at early stages of lexical access and do not move on to the final selection.
In L2 morphological processing, research is focusing on issues of morphological decomposition, and the linguistic conditions, such as the complexity and productivity of stem allomorphy in inflection or semantic transparency in derivation, that promote or impede morphological decomposition in L2 learners. Dual-route models of morphological processing proposed for L1 have been supported by neurological evidence (Bozic et al., 2010; de Diego Balaguer et al., 2006). In L2 learners, the issue is how much they rely on morphological decomposition, as opposed to whole-word storage and access under different conditions, and depending on their L2 proficiency level.

The role of expectancies in L2 lexical access of inflected words is explored in research on the influence of the inflectional paradigm on access speed, with reaction times supposedly indicative of decomposition costs in single word recognition. Indeed, in L1, expectancies based on the frequency of the particular inflected noun form within its inflectional paradigm interact with the expectancies based on the frequency of its case in the whole inflectional class of nouns. The degree of deviance in frequency of the actual noun form from the predictions based on the inflectional class has been quantified in the measure of relative entropy that positively correlates with the RTs in word recognition Milin et al. (2009). It is an open question how and when L2 learners develop a native-like system of expectancies for inflected word forms that are part of productive paradigms.

Finally, there is a possibility that L2 learners decompose inflected words to access their lexical meaning, and that the recomposition and rechecking stage necessary for the efficient processing of morphosyntactic information is less automatized. As in phonological aspects of L2 lexical access, L2 learners may tend to concentrate on earlier stages of lexical retrieval that ensures lemma access, and be less concerned about the processing of morphosyntactic information that becomes available when the stem and inflection are reintegrated in the whole word. In speech processing beyond the single word level, this morphosyntactic information is integrated with the sentence context, and it will be for future studies to explore the interaction of expectancy driven by the context and the mechanisms of morphological decomposition in lexical access.

12 According to an fMRI study of silent generation of regular and irregular Spanish-inflected verbs (de Diego Balaguer et al., 2006), regular and irregular verb inflection involves overlapping brain areas responsible for morphological decomposition, and also separate non-overlapping areas for regular and irregular verbs. The findings are interpreted as shared processing of regular and irregular verb inflections, with additional reliance on reactivation of the same stem in regular verb generation, as opposed to lexical search and retrieval of the additional stem for irregular verbs.