Spoken Word Recognition in Bilingualism

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Recognizing spoken words entails unique challenges for bilingual compared to monolingual listeners—where we take bilinguals to include any type of listeners who have functional command of two or more languages, whether they have acquired them from birth (i.e., as native or first language, hence L1) or learned some of them later in life (i.e., as a second language, hence L2). Spoken word recognition in one's L1 is usually effortless, but the same task can be much more demanding when listening to an L2. With a restricted vocabulary, it is sometimes impossible to understand parts of an L2 utterance. But even if a listener knows the words and is highly proficient in the L2, it is still harder to recognize spoken words in the L2 than in the L1. Difficulties with L2 word recognition become especially evident in real-life situations when speakers use casual rather than careful speech, speak with an accent that the listener is not familiar with, or when the conversation takes place in a noisy setting—such as a crowded pub. While people listening to the L1 (hence L1 listeners) are usually not aware of the complex cognitive processes underlying word recognition, listeners to the L2 (hence L2 listeners) are often painfully aware of the complexity of the task.

What then are those cognitive processes involved in spoken word recognition? In order to decode the message of a speaker, listeners must recognize individual words in the speaker's utterance. Spoken word recognition involves two central processes: (a) multiple word activation and competition and (b) segmentation of the continuous speech stream. The incoming speech calls up a set of potential word candidates that match with the unfolding input, and the activated word candidates immediately start competing for recognition before the end of the utterance has been reached (for models of spoken word recognition, see, e.g., Kleinschmidt & Jaeger, 2015; Magnuson et al., 2018; McClelland, 2013; Norris & McQueen, 2008). As the word *start* is heard, for example, words with similar sounds such as *star, steam, summer, tart,* and *art* will be considered in parallel with *start*. The fact that words resemble one another (e.g., *dry* and *try* only differ in the voicing of the initial consonant), that short words may be embedded within longer ones (e.g., *art* in *start*), and that the locations of word boundaries are not indicated complicates the task for the listener.

More Lexical Activation for Bilingual Listeners

The processes involved in spoken word recognition are thought to be universal. The question is thus not whether multiple lexical activation and competition occurs in bilingual spoken word recognition, but how much of it occurs. There is ample evidence that part of the effort of bilingual listening is caused by an increase in the competitor set, particularly when listening to the L2 and also when listening to the L1.

Competing Words from the Wrong Language

A major factor responsible for increasing the competitor set is that bilingual listeners are not able to keep their two lexica apart. They not only activate words from the right language, that is, the language they are listening to, but also words from the wrong language, that is, the

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unintended language. Thus, when listening to their L2, they also activate words from their L1. For example, when Dutch listeners hear the English word *leaf*, they not only activate *leaf* but also the similar-sounding Dutch word *lief*, meaning 'sweet' (Schulpen et al., 2003). Moreover, they also activate words from the L2 when listening to their L1, such that Dutch listeners activate the English word *leaf* when hearing Dutch *lief* (Lagrou et al., 2011). Words from their native language are also activated when the overlap with the second language only concerns word onset. Dutch listeners experience activation of the Dutch word *deksel*, 'lid', when hearing the English word *desk* (Weber & Cutler, 2004), and Russian listeners activate the Russian word *marku*, 'stamp', when hearing the English word *marker* (Marian & Spivey, 2003).

For bilingual listeners, the set of activated words is therefore not restricted to words that are phonologically similar within the language they hear but is enlarged by parallel activation of the two lexica, even when they listen to their L1 or are highly proficient in their L2. Luckily, contextual information can help listeners to restrain somewhat the activation of competitors from the wrong language. When a listener can predict which language a speaker will be using, words from the other language become less strongly activated (Molnar et al., 2015). Further, the activation of words from the other language is much reduced when they are semantically incongruent with a sentence's context (e.g., English listeners activate English *pool* less strongly in the French sentence *Marie va nourrir la poule*, 'Marie will feed the chicken' (FitzPatrick & Indefrey, 2010).

Competing Words from the Right Language When Sounds Are Easy

When listening to the L2, bilingual listeners also suffer from an increase in lexical activation from within the L2 itself. They are less efficient in deactivating unintended words than monolingual listeners are, even when the speech does not contain any sounds that L2 listeners find particularly difficult.

For example, Russian speakers of German can easily hear the difference between "f" and "t," as in the German words *Fisch,* 'fish', and *Tisch,* 'table'. When native listeners of German hear *Tisch*, they also briefly activate *Fisch,* due to the partial overlap of the words, and then quickly deactivate it again. For the Russian listeners, *Fisch* remains activated much longer—long enough for its meaning and word associations to be retrieved (Rüschemeyer et al., 2008). This problem has been ascribed to a less-detailed, or *fuzzy*, representation of L2 word forms in the mental lexicon. Thus, even when L2 listeners can very well hear the difference between certain speech sounds, they may fail to detect a mismatch between a word they hear and a particular word in their mental dictionary due to the vagueness of the stored word. This problem is greater for words that the L2 listeners are less familiar with (Cook et al., 2016).

Consequently, L2 listeners find it particularly difficult to recognize words with a large number of lexical "neighbors"—words in the mental lexicon that differ by a single sound. L1 listeners also find it harder to recognize words coming from a high-density neighborhood than words from a low-density neighborhood—because the more words are activated, the harder it is to recognize the intended word—but L2 listeners are much more affected by this than native listeners are (Bradlow & Pisoni, 1999).

Competing Words from the Right Language When Sounds Are Difficult

Perceiving differences between similar-sounding words is not always easy for L2 listeners. This is due to the fact that L2 sound perception is often inaccurate (for an overview, see Wayland, 2021). In particular, discrimination of L2 sound contrasts that do not play a role in the listeners' native language may never reach native standards. Japanese listeners, for example, have notorious difficulty in distinguishing English /r/ and /l/, which both map (poorly) to a single Japanese category which is phonetically between /r/ and /l/. Dutch listeners find it difficult to perceive the difference between the English /æ/ (the vowel in *cat*) and /ɛ/ (the vowel in *desk*), and even highly fluent

Spanish–Catalan bilinguals who have acquired both languages early in life have difficulty distinguishing Catalan /e/ and /ɛ/. The problem of fuzzy representation of L2 words in the mental lexicon is particularly strong for words containing these difficult nonnative sounds. Thus, even when listeners manage to identify such sounds accurately in isolation, they still have trouble recognizing words containing those sounds due to the lack of precision in the way the words are stored in the mental lexicon (Llompart, 2021). These perceptual difficulties with L2 sounds, and their concurrent fuzzy representation in the lexicon, affect L2 word recognition in at least three ways.

First, the distinction between minimal pairs can get lost. Dutch L2 listeners of English do not treat minimal pairs such as *flash* and *flesh* as two different words; rather, hearing *flash* also leads to the activation of *flesh* (Cutler & Broersma, 2005). Similarly, even highly fluent early Spanish–Catalan bilinguals show the same effect when listening to Catalan minimal pairs such as *néta*, 'granddaughter' and *neta*, 'clean', differing in the sounds /e/ and /ɛ/ that are not contrasting in Spanish (Pallier et al., 2001). Luckily, this is not a frequent problem. The number of minimal pairs in the English lexicon, for example, is relatively small, especially when compared to the number of homophones (e.g., *rain—reign*) that listeners have to handle anyway (Cutler, 2005). An increase in lexical competition due to the misperception or fuzzy representation of minimal pairs therefore occurs only rarely.

Second, words with different onsets are treated as matching in onset when perceptually difficult sounds are involved. When listeners hear a word, all words with overlapping onsets are initially activated. Thus, upon hearing the first syllable of *panda*, English L1 listeners activate not only *panda* but also *panel*, *panic*, and *pantry*, among others. As soon as more than the first syllable is heard, the activation of the incorrect word candidates decreases, and by the time the whole word *panda* has been heard, no activation of the incorrect candidates remains. For L2 listeners, however, this initial set of competitor words is expanded by words that differ in a perceptually difficult sound contrast in the initial portion of a word. That is, for Dutch listeners, hearing English *pan-* additionally activates words such as *pencil*, *penny*, and *pension* (Weber & Cutler, 2004). Similarly, for Japanese listeners, hearing *rocket* causes temporary lexical activation of *locker* (Cutler et al., 2006). Since the overlap in these cases is only temporary, the initial confusion will not lead to a lasting misinterpretation of which word is being heard. Nevertheless, the extended availability of incorrect interpretations slows down the L2 word recognition process. Analysis of the English vocabulary has shown that this type of confusion occurs frequently and causes substantial added lexical competition for L2 listeners (Cutler, 2005).

Third, parts of words that resemble an entire embedded word cause unwanted lexical activation. When English L1 listeners hear the word *DEFinite*, this also temporarily activates the embedded word *deaf*. For L2 listeners, however, this can extend to cases where the speech signal does not actually contain an embedded word but an embedded "near-word." Thus, for Dutch L2 listeners who hear English *DAFfodil*, containing the near-word *daf*, the word *deaf* is also activated, while this is not the case for English L1 listeners (Broersma & Cutler, 2011). Similarly, native listeners of Dutch, which distinguishes voiced and voiceless consonants but not in word-final position, activate *groove* when they hear the near-word *groof* as part of the sequence *biG ROOFs* (Broersma & Cutler, 2008). Again, similar results have been found for highly fluent early Spanish–Catalan bilinguals (Sebastián-Gallés et al., 2005). Listeners will eventually solve the misunderstanding because an erroneous parsing of the speech signal leads to meaningless leftovers (e.g., a person who hears *deaf* in *daffodil* will be left with *–odil*), but this still requires an effortful and time-consuming detour. Again, analysis of the English vocabulary has shown that the problem of embedded near-words occurs very frequently (Cutler, 2005).

In addition to sound recognition difficulties, the so-called "stress deafness" can also cause spurious lexical activation. In French, stress is not used contrastively. Hence, French listeners of English cannot distinguish the first syllables of *mystery* and *mistake* (Tremblay, 2008), and French listeners of Spanish interpret a near-word such as *gorro* as the Spanish word *gorro*, 'hat' (Dupoux et al., 2008).

Difficulties of Segmenting Speech into Individual Words for Bilingual Listeners

Word recognition would be much easier if the beginning and ending of words were as clearly marked in speech as in written language, where blank spaces indicate word boundaries. But speech is a continuous stream of sounds, and listeners must segment the stream into recognizable units (i.e., words) themselves. Pauses in speech are no help in locating word boundaries, as they regularly occur within words and are often missing between words. Listeners thus must use other information to locate word boundaries in an utterance, including lexical subtraction, prosodic and phonotactic structure, and fine phonetic detail. Listeners are often less efficient in exploiting these language-specific information sources in their L2, mostly because their L1 segmentation strategies interfere.

Lexical Subtraction

Recognizing one word helps listeners find other words. When listeners recognize a word they know, especially when it is a long word that is not likely to be part of another word, they expect the onset of a new word to follow. Thus, when they hear *anythingcorri*, they recognize 'anything' and expect *corri* to be the beginning of a new word (e.g., 'corridor'). In such cases, L1 and L2 listeners benefit equally from the use of lexical knowledge for segmentation (White et al., 2010)—provided that they know the words.

In other cases, when an utterance contains shorter words that could be parsed in more than one way, lexical subtraction is less straightforward. For example, when listeners hear *mildoption*, they can interpret the beginning to contain either 'mild' or 'mile', but while the first interpretation leaves the real word 'option' to follow, the second interpretation entails a meaningless leftover *(doption)*. In such cases, L1 listeners find it easier to use their lexical knowledge to find the correct parsing than L2 listeners who might be less certain that 'doption' is not a word (Mattys et al., 2010).

Prosodic Structure

The rhythm, intonation, and stress pattern of an utterance, together called 'prosody', contain information about how the parts of the utterance are grouped together. Prosody is thus a source of information that listeners can use for speech segmentation.

One strategy that listeners use to facilitate segmentation of running speech is based on the specific rhythmic structure of their L1. In English and Dutch, for example, most words begin with a stressed syllable, and native listeners of those languages thus favor stressed syllables as likely locations for the beginning of new words. Native listeners of languages such as French and Japanese, on the other hand, use the onsets of syllables and moras, respectively, as likely locations for word boundaries. When listening to an L2, unfortunately, listeners tend to use the segmentation strategy they know from their L1. French listeners, for example, persist in using the syllable-based segmentation strategy that is appropriate for French when they listen to English (Cutler et al., 1986) or Japanese (Otake et al., 1993), where it is not helpful.

Listeners also use intonation for the segmentation of continuous speech. In French, for example, a pitch rise can signal the end of a phrase, and native French listeners use this regularity to locate likely word endings. English and Korean listeners of French, on the other hand, find it difficult to use this prosodic information (Tremblay et al., 2016).

Phonotactic Structure

The probabilities of sound sequences within syllables (so-called 'phonotactic' probabilities) are another information source used for speech segmentation. For example, in English, /sl/ as in *sleep* is a legal syllable onset but /ʃl/ ('shl') is not, and while a boundary between /s/ and /l/ is

possible but not required, /ʃl/ clearly marks a syllable boundary—and therefore also a possible word boundary—in English. This knowledge helps English native listeners to detect the English word *lunch* in *glarshlunch*. In German, on the other hand, /ʃl/ as in *Schlaf*, 'sleep', is a legal syllable onset but /sl/ is not. Highly proficient German speakers of English use both L1- and L2-specific knowledge to segment English speech. Their knowledge of English phonotactics helps them detect the English word *lunch* in *glarshlunch*, but their interfering German phonotactic knowledge also leads to facilitated detection of *lunch* in *moycelunch* (Weber & Cutler, 2006).

Further, native listeners avoid segmenting the speech stream in ways that form leftovers that cannot possibly form a syllable. This is called the Possible-Word Constraint (Norris et al., 1997). Native listeners of English, for example, find it easier to recognize *apple* in *vuffapple* than in *fapple*, as the leftover *vuff* is a legitimate syllable in English but *f* is not. While L2 listeners apply the same principle, their knowledge of what is a possible syllable in their L1 interferes during L2 listening (Hanulíkóva et al., 2011).

Phonetic Detail

Fine phonetic differences in how a sound is pronounced can also provide information about word boundaries. For example, the /t/ is pronounced with aspiration in the phrase *keeps talking* but without aspiration in *keep stalking*. English listeners use these pronunciation differences to decide which phrase they heard. L2 speakers, on the other hand, cannot use this information as efficiently. Thus, both Spanish and Japanese speakers of English distinguish between the two interpretations much less accurately than English native listeners do (Altenberg, 2005; Ito & Strange, 2009).

Challenges, Opportunities, and Benefits of Bilingual Word Recognition

As described above, one major challenge in bilingual listening is that more words compete for recognition for bilingual listeners, particularly when listening to their L2. For bilingual listeners, the set of potential word candidates is multiplied with parallel activation of words from the wrong language, as well as words from the intended language that native listeners would not consider, or would deactivate much faster, during recognition. The processes of lexical activation and competition in spoken word recognition are determined by phonological overlap between the speech input and words in the lexicon. But in L2 listening, the notion of phonological overlap gets a different meaning as L2 listeners can experience overlap where L1 listeners do not.

Luckily, L2 listeners have opportunities to overcome this challenge. As listeners become more proficient in an L2, their word recognition skills also improve. L2 listeners, who have a larger vocabulary and can distinguish difficult L2 sounds better, also have more robust, less-fuzzy lexical representations in their mental lexicon (Llompart, 2021). Furthermore, explicit instruction can help listeners recognize sounds more accurately, which in turns helps them recognize words, such as minimal pairs like *flash* and *flesh* for Dutch listeners of English, more accurately (Felker et al., 2021). Highly proficient bilinguals can become very sensitive to subtle differences between L2 speech sounds and reach a precision in L2 word recognition that is similar to that of L1 listeners (Desmeules-Trudel & Zamuner, 2021). Similarly, L2 learners can improve the recognition of stress in L2 words; for example, Dutch listeners distinguish the English words *desert* and *dessert* better as their proficiency increases (Tremblay et al., 2021).

Another challenge contributing to the difficulty of bilingual word recognition, as described above, is that L2 listeners are less efficient than native listeners in segmenting the continuous speech stream into individual words. For L1 listeners, the task of segmentation is facilitated by numerous indications to word boundaries, including lexical subtraction, prosodic cues, phonotactic constraints, and phonetic detail. Although L2 listeners can exploit these cues to some extent, they often cannot do so as successfully as L1 listeners.

Luckily, again, there are opportunities to overcome this challenge. As learners become more proficient in an L2, their segmentation of the continuous speech stream also improves. Further, targeted training can improve L2 speech segmentation skills (Farrell, 2015). Recommendations for classroom activities aiming to improve various aspects of L2 word recognition, including segmentation skills, are offered by Cutler and Farrell (2018).

The capacity for implicit learning also turns out to be larger for adult L2 learners than previously thought. Learners can successfully extract segmental, phonotactic, and lexical knowledge about an unknown language from just a few minutes of uninstructed listening to an unfamiliar language (Gullberg et al., 2010; Webb, 2020).

A benefit of L1 knowledge arises when L2 listeners listen to speech produced by another nonnative speaker with the same L1 as the listener. L2 listeners recognize words more easily when the speaker has the same native language. Thus, Russian speakers of Hebrew recognize Russian-accented Hebrew words faster than Arabic-accented Hebrew words (Leikin et al., 2009), and Dutch speakers of English recognize Dutch-accented English better than Japanese-accented English (Weber et al., 2011) or German-accented English (Hanulíkóva & Weber, 2012). These effects have been explained as long-term adaptation to the accent that the L2 listeners hear the most (i.e., the accent typical of the speakers around them).

Adult L2 learners have a wealth of linguistic and nonlinguistic knowledge that they bring to the task of acquiring an L2. For example, they have a set of phonemic categories that will partially overlap with the L2, they know about words and how they are structured, they have conceptual representations for concrete and abstract objects, they can often draw on orthographic knowledge for learning new word forms (Escudero et al., 2008; Kaushanskaya & Marian, 2009), and some of the words in their L1 and L2 might overlap—the so-called cognates—which makes these words easier to recognize (Frances et al., 2021). Having an L1 already can therefore also be beneficial for second language acquisition and for bilingual spoken word recognition.

SEE ALSO: Bilingualism and Cognition; Bilingualism and Speech Perception; How Bilinguals Read Words in Their Two Languages (Lexical Access in Visual Word Recognition in Second Language Processing); Formal Models of Bilingual Lexicons; Spoken Word Recognition

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