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Research Article

Training-induced pattern-specific phonetic adjustments by first and second language listeners



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ABSTRACT

The current study investigated the phonetic adjustment mechanisms that underlie perceptual adaptation in first and second language (Dutch-English) listeners by exposing them to a novel English accent containing controlled deviations from the standard accent (e.g. /i/-to-/i/ yielding /krɪm/ instead of /kri:m/ for 'cream'). These deviations involved contrasts that either were contrastive or were not contrastive in Dutch. Following accent exposure with disambiguating feedback, listeners completed lexical decision and word identification tasks. Both native and second language listeners demonstrated adaptation, evidenced by higher lexical endorsement rates and word identification accuracy than untrained control listeners for items containing trained accent patterns. However, for L2 listeners, adaptation was modulated by the phonemic contrast, that is, whether or not it was contrastive in the listeners' native language. Specifically, the training-induced criterion loosening for the L2 listeners was limited to contrasts that exist in both their L1, Dutch, and L2, English. For contrasts that are either absent or neutralized in Dutch, the L2 listeners demonstrated relatively loose pre-training criteria compared to L1 listeners. The results indicate that accent exposure induces both a general increase in tolerance for atypical speech input as well as targeted adjustments to specific categories for both L1 and L2 listeners.

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1. Introduction

1.1. Perceptual adaptation for native listeners

Native (L1) listeners of a language possess a remarkably flexible perceptual system that enables them to extract linguistic information from degraded or impoverished speech signals, to identify different talkers with a high degree of accuracy, and to adapt to variability that arises as a function of differences in talker or accent (Cutler, 2012). Adaptation to talker-specific characteristics, such as a foreign accent, occurs rapidly, within a few minutes of exposure (Clarke & Garrett, 2004) and can subsist for several days without any intervening exposure (Eisner & McQueen, 2006; Kraljic & Samuel, 2005). Prior research has suggested that adaptation to patterns of deviation from native-accented norms arises from listeners' ability to utilize contextual information, including lexical (e.g., Eisner & McQueen, 2005; Kraljic & Samuel, 2007; Zhang & Samuel, 2014), phonotactic (Cutler, McQueen, Butterfield, Norris, &

Planck, 2008) and visual information (e.g., Bertelson, Vroomen, & De Gelder, 2003) to interpret these deviations (e.g., determine that [wɛtʃ] is likely *witch* /wɪtʃ/) and adjust the relevant phoneme category boundaries as necessary. Moreover, foreign-accented speech also appears to be processed gradually, whereby the strength of the accent influences the speed and accuracy of word recognition (Porretta, Tucker, & Järviö, 2016).

The specificity of perceptual learning has also been the subject of investigation (e.g., Baese-Berk, Bradlow, & Wright, 2013; Bradlow & Bent, 2008; Eisner & McQueen, 2005; Kraljic & Samuel, 2005, 2006; Kraljic & Samuel, 2007; Reinisch & Holt, 2014; Reinisch & Mitterer, 2016; Sidasas, Alexander, & Nygaard, 2009), with a number of factors implicated in whether or not listeners will generalize learning to novel talkers, including the type of phonetic contrast involved, the amount of relevant variation in the signal and the acoustic similarity of the talkers. For example, when presented with multiple talkers who share the same foreign accent, perceptual learning was more likely to generalize to a novel talker of the same accent than if exposed to a single talker (Bradlow & Bent, 2008; Sidasas et al., 2009). High variability training is

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posited to promote generalizable learning, as it allows for the extraction of systematic patterns of deviations from native-accented norms shared by the talkers, resulting in more robust and generalizable adjustments. However, there have been cases where single talker training on a regional accent characteristic has been found to transfer to a novel talker, which has been attributed to the acoustic similarity between the trained and novel talkers (e.g., Reinisch & Holt, 2014).

Importantly, prior work has demonstrated systematic (or constrained) adaptation as opposed to unconstrained across-the-board criterion loosening. Maye et al. (2008) examined native listeners' adaptation to a novel accent of English by comparing performance in an auditory lexical decision task following two different exposure phases: (1) a 20-min story produced with a Standard American English accent, and (2) the same story where all instances of front vowel pronunciations were lowered. Following exposure to the novel accent, a significant increase in lexical endorsement rates in the lexical decision task was found for lowered front-vowel items but not raised front-vowel items. This suggests that adaptation processes involved direction-specific, targeted phonetic adjustments rather than relatively unconstrained, general category broadening. Weatherholtz (2015), using a similar paradigm, found that the enhanced word recognition following accent exposure generalized to novel items as well as to novel talkers, despite listeners being initially exposed to only a single talker. Unlike Maye et al. (2008), listeners were also found to generalize their exposure to untrained, structurally-related vowel chain shifts. That is, following exposure to a system of back vowel lowering, enhanced word recognition was found when tested on a system of back vowel raising or front vowel lowering. However, exposure to a system of back vowel raising did not yield generalization to back vowel lowered pronunciations, suggesting that adaptation processes may involve a combination of general category broadening and targeted category shifts. Evidence for this mechanism of general category expansion has also been implicated in accent adaptation with young children (Schmale, Cristia, & Seidl, 2012; Schmale, Seidl, & Cristia, 2015).

1.2. Non-native speech perception and learning

Despite the precision and flexibility of native language listening, speech perception in one's second language can be a challenging task, arising from difficulties at multiple levels of linguistic processing (e.g., Best & Tyler, 2007; Broersma & Cutler, 2008; Flege, 1995). As a result of inaccurate L2 phoneme perception, L2 spoken word recognition can become problematic. Words such as *peck* and *pack* for Dutch listeners or *rice* and *lice* for Japanese listeners are often indistinguishable from each other (Broersma & Cutler, 2008; Logan, Lively, & Pisoni, 1991). L2 listeners have the added challenge of contending with more lexical competitors during word recognition than L1 listeners, as a product of the activation of "phantom" competitors (Broersma & Cutler, 2008; Cutler & Broersma, 2005). For instance, in a lexical decision task, near-word items such as "flide" or "shib" would be considered non-words by native English listeners but more often as real words by native Dutch listeners (perceiving them as *flight* and *ship*, respectively), as a result of voicing not being distinc-

tive word-finally in Dutch. Indeed, in a cross-modal priming paradigm, Dutch listeners' perception of the targets were significantly facilitated both when the prime item matched (*flight*-*FLIGHT*) as well as when the prime item was a near-word (*flide*-*FLIGHT*), whereas this facilitation was only found in the matched condition for English listeners. A similar pattern of results was found with the /æ/-/ɛ/ contrast, which is also not distinctive in Dutch (Cutler & Broersma, 2005). This indicates that perceptual phonetic confusions and phantom activation can lead to an increase in the amount of lexical competition with which an L2 listener has to contend, and a greater degree of lexical competition has been demonstrated to yield slower word recognition (e.g., Norris, McQueen, & Cutler, 1995).

However, there is evidence to suggest that L2 listeners can achieve comparable performance (or even surpass) native listeners when listening to foreign-accented speech (that is, speech produced by other L2 speakers), particularly when the talker and listener share an L1 background (Bent & Bradlow, 2003; Hayes-Harb, Smith, Bent, & Bradlow, 2008; Imai, Walley, & Flege, 2005; van Wijngaarden, 2001; Xie & Fowler, 2013). For example, using a cross-modal priming paradigm, Weber, Broersma, and Aoyagi (2011) found facilitated processing when the acoustic manifestation of the foreign-accented prime item aligned with the accent of the listeners (Japanese vs. Dutch). For example, the item /ɛkt/ primed the English word *act* for Dutch listeners, whereas /'akto/ primed *act* for Japanese listeners (and did not for Dutch listeners). Similarly, Hanulíková and Weber (2012) also reported the influence of linguistic experience on the perception of foreign-accented pronunciation variants. The eye movements of German and Dutch learners of English were tracked when perceiving words containing three variants (/s/, /f/, /t/) of the pronunciation of the English interdental fricative /θ/. Despite /f/ being the most perceptually confusable with /θ/, listeners' looking preferences aligned with the pronunciation variant most frequently produced by listeners of the different language groups (German-accented English is characterized by /s/-substitutions, while Dutch-accented English is marked by /t/-substitutions). Knowledge or familiarity with the particular deviation patterns that result from a specific L1–L2 language pair may better equip listeners to interpret the speech produced by a speaker with this particular language background.

As noted above, one of the hallmarks of L1 listening is the ability to flexibly adapt to variable speech input (Cutler, 2012), and within the context of the L2 speech perception research reviewed above, recent work has begun to examine whether and how perceptual adaptation works for L2 listeners (e.g., Mitterer & McQueen, 2009; Reinisch, Weber, & Mitterer, 2012; Schertz, Cho, Lotto, & Warner, 2015; Weber, Di Betta, & McQueen, 2014). Mitterer and McQueen (2009) reported that Dutch listeners exposed to Scottish or Australian English accented speech on television were able to leverage English language subtitles to improve their comprehension relative to control listeners who either received Dutch subtitles or no subtitles. Listeners who received English subtitles were significantly more accurate at repeating back phrases produced by Australian- and Scottish-accented speakers as compared to the control groups who did not receive any training. As these L2 listeners demonstrated an ability to utilize lexical (as well as audio-visual and other sub- and supra-lexical) cues to adapt

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