Attested correlations between the perceptual development of L2 phonological contrasts and target-language production confirm the Gradual Learning Algorithm

Summary

The formal Gradual Learning Algorithm predicts that the development of the weighting of acoustic cues in the perceptual acquisition of phonological contrasts, reflects the availability of these cues in the target language. For this paper, we measured a regional variation in the production of the English /ɪ/-/iː/ contrast, and observed that this variation indeed correlates with a regional variation in the weighting of the acoustic cues in the perception of this contrast, as measured in an earlier experiment.

Abstract

Boersma's (1998) three-grammar model of phonology contains a separate perception grammar, implemented as an Optimality-Theoretic grammar that handles, among other things, the classification of raw acoustic material into discrete phonological categories. If the general Gradual Learning Algorithm (for its application to production, see Boersma & Hayes, to appear) is applied to the acquisition of this perception grammar, the learner automatically develops a perceptual bias that reflects the relative frequencies of the various acoustic values in her language environment (Boersma 1997).

Some phonological contrasts are characterized by multiple acoustic cues. The English vowels /ɪ/ and /iː/, for instance, differ in vowel height (first formant) and length (duration). Listeners are expected to rely both on the height cue and on the length cue when distinguishing between these vowels. But the availability of the two cues shows regional variation. In Scottish English, for instance, /iː/ is much shorter than in Southern English, so that the actually produced durations of Scottish /ɪ/ and /iː/ overlap appreciably. In Southern English, on the other hand, /ɪ/ is higher than in Scottish English, while /iː/ is lower, so that the actually produced first formants of Southern /ɪ/ and /iː/ overlap.

By feeding actually recorded tokens of /ɪ/ and /iː/ by a Scottish and a Southern English speaker to the Gradual Learning Algorithm in the perception grammar, we will show that this algorithm predicts that Scottish listeners will learn to rely mainly on height, and Southern English listeners mainly on length, i.e., that cue reliance depends on cue reliability. This is a desirable result for any learning algorithm: it minimizes the probability that the listener miscomprehends the speaker's utterance. The formal Gradual Learning Algorithm, therefore, provides a blind mechanism that implements the functional principle of minimization of perceptual confusion.

The predicted correlation between production and perception is borne out by perception experiments. Escudero (2000a, to appear) found that the average Standard Scottish English listener indeed relies almost exclusively on height, while Spanish speakers of English were divided into four groups: no perceptual distinction between the two vowels (S0), an exclusive

reliance on length (S1), a reliance on both length and height (S2), and an almost exclusive reliance on height (S3). Apparently, listeners use different perceptual strategies, depending on their L1 and L2. Escudero (2000b) hypothesized that this perceptual variation is partly caused by a regional variation in production, since the S1 group tended to have a history of learning the Southern English variant.

To predict such developmental stages in the perceptual L2 acquisition of the /ɪ/-/iː/ contrast, we let the learning algorithm simulate the behaviour of a virtual Spanish speaker who goes to live in Southern England and later moves to Scotland. This simulated listener starts with a copy of her Spanish perception grammar, in which the height and length reliances are zero since Spanish has no [ɪ]-[i]-like height contrast and no length contrast (this is Escudero's state S0). The learner then repeatedly "hears" Southern English words with /ɪ/ and /iː/, which we recorded from a real Southern English speaker. Every time she miscomprehends a word, the learner reranks some constraints in her perception grammar. Gradually, she comes to rely on both length and height (S1, S2) and achieves native-like comprehension. This comprehension deteriorates when she is subsequently exposed to (real) Scottish English words. With time, however, she reverses the weighting of the two cues: she comes to rely almost exclusively on height (S3) and returns to proficient comprehension.

Thus, the four attested, possibly sequential, patterns or stages in the weighting of acoustic cues in L2 phonological acquisition, lend confirmation to the formal three-grammar model of Functional Phonology and to its associated Gradual Learning Algorithm.

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