Where's the contrast?

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Introduction

Distinctive feature theory locates contrast in the opposition of discrete featural properties. Some theories have innate and universal features: *SPE* or versions of OT with features embedded in the constraints. Responding to obvious problems with the variability of language(s), other theories let features emerge, either within one speaker's learning, or within the development of language(s) [Mie08].

Contrariwise, exemplar approaches abandon categories, leaving only fuzzily separated clouds of points in phonetic space, or even just clouds of word traces. Examplars deal nicely with word-specific phonetic detail, social indexing etc. – but where's the contrast?

Hybrid models (e.g. [Pie02]) combine 'modular feed-forward' phonology with exemplar theory; so still have to address the issue of phonological representations, and where's the contrast? In distinctive features??

Two questions: are distinctive features a good model, and are they part of the mental representation of language? The main techniques used are experiments on people, to show an observed effect that is (or is not) consistent with the predictions of a theoretical model, and simulations, to show that a theoretical model can generate an observed effect.

In this project, we take as a starting point one example from each of these two strands: [BC10], which uses simulations in Boersma's bidirectional OT-based theory to argue that features are supported by differing perceptual boundaries between vowels in different languages (Czech and Spanish); and [Kin03], which uses experiments on American English speakers learning to recognize German vowels to argue that the learners are (sometimes) recognizing distinctive features rather than just doing category assimilation.

Objectives: investigate by simulation to what extent previous results necessarily reflect differences between models, and so to see how robust are inferences about the source of contrast.

Basic simulation framework

The framework follows the style of [dB01]. An agent learns vowels from surrounding agents via 'imitation games' – the learner tries to match a vowel said by the teacher, and receives extra-linguistic feedback on whether it succeeded; if not, they adjust their phoneme inventory by shifting a vowel or adding a new vowel, depending on various criteria.

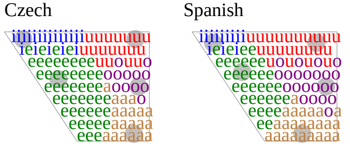
In the first simulation, we are modelling acquisition, so baby agents start with *tabulae rasae*; they learn from an adult population, and as they become adult, their inventory fixes. Variation arises from articulatory and acoustic noise. Gradually the initial adult population dies and new agents are born.

In the second simulation, we model adults learning non-native distinctions. Here the adult is learning 'foreign' vowels, either by matching to native vowels or by adding new vowels.

In both simulations, vowels are abstract phonetic objects in *n*-space, and there are (currently) no inbuilt categories. In the first, agents have a hybrid model in which they learn a region of vowel space bounded by the exemplars they hear, and produce tokens weighted towards the centre of that region; in the second, a simply prototype model (at present – hybrid version planned).

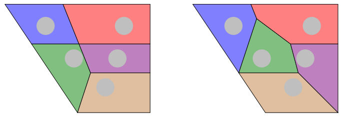
Czech vs Spanish vowels

Czech and Spanish speakers (both /a,e,i,o,u/ languages) divide the perceptual vowel space differently, shown by the Turku Vowel Test:



Adapted from [Sav09]. Acoustic F_1, F_2 space. Humans judging artificial vowels. Colours show perceptual regions. Grey blobs show areas judged 'best' representatives.

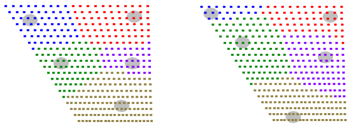
[BC10] ran a larger Czech/Spanish study, with slightly different results, and then showed that the perceptual differences could be explained by different feature categorizations for Czech (a/e back/front) and Spanish (a/e both central) learners as they acquire the contrasts via a bi-directional OT grammar from the *same* examplars:



Schematic adapted from [BC10]. Notional F_1, F_2 space. Bidi stochastic OT agents. Colours show perceptual regions after training. Grey blobs show centre of distributions used in training.

Note boundaries following axes in 'Czech', vs diagonal boundaries in 'Spanish'. [BC10]'s experimental perceptual boundaries with real Czech and Spanish are reported to follow this pattern.

Here we demonstrate that the differing patterns can also be explained solely as a result of the differing prototypes.



Agents learning from initial vowel inventories marked by blobs. Shades map perceptual boundaries of a new adult after a couple of generations. Vowels are abstract F_1, F_2 pairs.

- Can differing contrasts arise from differing features? Yes – [BC10] show this. But: feature analyses of Czech vowels are not agreed – e.g. [Bič11] argues Czech /a/ should be [central], not [back]. And: where do the features come from?
- Can they arise from differing vowels? Yes – we show this. But: available literature on production data suggests production norms are not perfectly aligned with perceptual prototypes. And: simple simulations are sensitive to parameter settings.
- How can we decide whether there are features? Next idea: look at learning when there should already be a feature system in place (if they exist) . . .

Learning Foreign Vowels

[Kin03] is a detailed experimental study aiming to detect the presence or absence of features in (American) English vowel systems by looking at learning of German vowels. It makes several comparisons between models of learning. We consider one (§4):

In brief, Eng. and Ger. both have several tense/lax pairs in non-low position: i/ɪ e/ɛ u/ʊ o/ɔ. Ger. also has y/ʏ ø/œ. When Eng. speakers learn Ger. front rounded, do they:

- learn exemplars in phonetic space?
- do this with 'selective attention' (Nosofsky '86) to dimensions relevant to the contrast?
- extract categories? (With all the problems of [tense] as a feature. . .)

Results mixed: [±high] and [±back] seem to be learned, [±tense] may or may not.

Predictions of the various models are made with purely qualitative arguments. We ask whether simulations agree with these.

Set-up: simple agents with prototypes. (Richer models harder to do in more dimensions . . . coming soon.) 'English' speakers have abstract version of Eng. inventory. They learn from a 'German' speaker that also has front rounded vowels. Two models initially:

- vowels are perceived and learned in acoustic perceptual space;
- vowels are perceived and mapped into space with dimensions including featural aspects (e.g. periphality as cue for tenseness) – modelling selective attention.
- in future: various models of binary features.

First phase: general evaluation of models. **First result:** 'Selective attention' learners learn twice as fast as exemplar learners. **First problem:** Formalizing exposes unclarity in the informal models. ('What *is* feature learning?')

Second phase: simulate training experiments of [Kin03]. In progress . . .

References

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