

How sensory substance can vary while phonological representations stay the same

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Abstract

Constraint templates based on articulatory and perceptual principles handle spoken and signed phonology in a uniform way.

The mapping from sensory (overt) form to phonological (surface) form can change within a speaker, while the phonological form stays constant. Therefore, surface phonological units are arbitrary.

A. MODALITY-INDEPENDENT MODEL OF PHONOLOGY

For spoken language: Boersma 1998. For signed language: Crasborn 2001.

A1. MODALITY-INDEPENDENT COMPREHENSION MODEL

sensory rep.	→	phonological rep.	→	lexical rep.
'overt form' (concrete) (continuous)		'surface form' (abstract) (discrete)		'underlying form' (abstract) (discrete)
[[ʔe_P]]	→	/#ep/	→	/#b# 'low tide'
[[wrist ext. 20°, MCP ext. 20°]]	→	/setting: close, away/	→	setting: close, away 'say'

A2. MODALITY-INDEPENDENT PRODUCTION MODEL

lexical rep.	→	{ articulatory rep.	⇒	sensory rep.	→	phonological rep.
'underlying form' (abstract) (discrete)		(concrete) (continuous)		(concrete) (continuous)		'surface form' (abstract) (discrete)
/#b# 'low tide'	→	{ [ʔep]	⇒	[[ʔe_P]]	→	/#ep/ }
setting: close, away 'say'	→	{ [shoulder in 45°, wrist ext. 20°, ...]	⇒	[[wrist ext. 20°, MCP ext. 20°]]	→	/setting: close, away/ }

A3. WHY PERCEPTION IS NOT 'JUST' PHONETICS

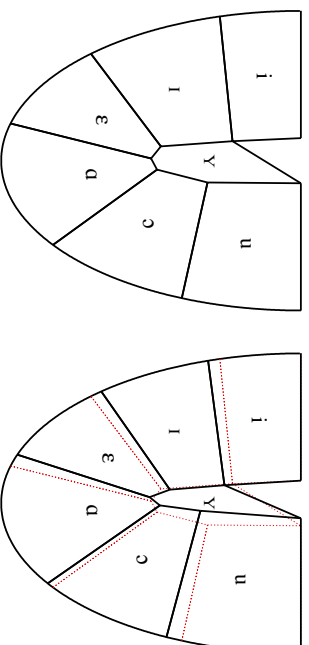
1. Perception (the mapping from sensory to phonological rep) occurs twice above.
2. Even perception is phonology. Why?
3. Because perception is language-dependent. What does that mean?
4. It means that speakers can maintain two perceptions at the same time.
5. To prove this, we only have to attest either of the following cases:
 - (a) a case where sensory reps are the same, but phonological reps are different, or
 - (b) a case where phonological reps are the same, but sensory reps are different.
6. Since sensory reps are continuous and phonological reps are discrete, cases of (5a) are difficult to prove. That's why this poster shows you a case of (5b).

B. EXPERIMENT TO PROVE DOUBLE PERCEPTION

Speakers listen in a different way to the same sounds when they think the language is their L1 than when they think the language is their L2.

B1. L1 CLASSIFICATION UNDER L1 PRIMING

38 Dutch listeners (Escudero & Boersma 2002) classified 125 vowel tokens, choosing from the 12 Dutch monophthongs. Although the listeners were told that the vowels were Dutch, the vowels had actually been cut from a Spanish text read by a native speaker from Madrid. The picture at the left shows how the listeners divided up the stimulus space.



B2. L1 CLASSIFICATION UNDER L2 PRIMING

In a second task, the same Dutch listeners classified the same 125 vowel tokens again, choosing from the same 12 Dutch monophthongs. However, this time the listeners were truthfully told that the vowels were Spanish. All 38 listeners were actually learners of Spanish (11 beginners, 18 intermediate, 9 advanced). The picture at the right shows how the listeners divided up the stimulus space when thinking the language was Spanish (the red dotted lines repeat the left picture for comparison).

B3. INTERPRETATION: SAME PHONOLOGICAL REPS:

L2 REUSE OF SELECTED EXISTING L1 CATEGORIES

Under Spanish priming, the learners avoid the Dutch /ɪ/ and /ʏ/, and respond more with the five Dutch vowels /ɑ/, /ɛ/, /ɪ/, /ɔ/, /u/. Apparently, these are the vowels to which they equate the five Spanish vowels /a/, /e/, /i/, /o/, /u/. In other words, L2 Spanish has the vowels /ɑ/, /ɛ/, /ɪ/, /ɔ/, /u/ for Dutch learners. Thus, the L2 surface representations are identical to the L1 surface representations.

B4. INTERPRETATION: DIFFERENT SENSORY REPS:

DEVELOPMENTAL BOUNDARY SHIFT AND CATEGORY LOSS

The mapping from sensory to surface representations changes in two ways:

1. The L2 /ɛ/-/ɑ/ and /ɑ/-/ɔ/ boundaries are less back than the L1 /ɛ/-/ɑ/ and /ɑ/-/ɔ/ boundaries. This corresponds to the fact that the Dutch /ɑ/ is more back than the Spanish /ɑ/.
2. The vowels /ɪ/ and /ʏ/ are not perceived as L2 categories.

B5. IMPLICATION: PHONOLOGICAL REPS ARE ARBITRARY

Phonological surface representations have no fixed connection to sensory stuff. Taking this to the extreme, we propose that they are completely arbitrary: any phonological unit can refer to any sensory dimension, so that the connection of the arbitrary phonological symbol to sensory stuff has to be learned during acquisition. Hence, there is no objection to the idea that auditory-based and visual-based surface units are recruited from the same space. Here are two theories compatible with this:

empiricist	arbitrary symbols created on the basis of clustering in a sensory dimension	arbitrary symbols available from the start, with initial perceptual mappings (even for sign language!)
	accurate mapping from multiple sensory dimensions learned later under supervision of the lexicon	accurate mapping from multiple sensory dimensions learned later under supervision of the lexicon

C. FORMALIZATION: OT PERCEPTION GRAMMAR

Perception is language-dependent, hence should be formalizable by linguistic means, for instance by a stochastic Optimality-Theoretic perception grammar (Boersma 1998). Once an arbitrary symbol is available, there will be constraints against mapping any value on any sensory dimension to any symbol, e.g., "an F1 of 450 Hz is not /e/'. The ranking of such constraints can be learned with the help of the Gradual Learning Algorithm (Boersma & Hayes 2001) under supervision of the lexicon. This even leads to an accurate weighting of sensory cues in perception (Escudero & Boersma 2001).

See the simulations with dancing constraint families!

CONCLUSIONS

1. Perception is phonology.
2. Surface representations are arbitrary.

References

- Boersma, Paul (1998). *Functional phonology: Formalizing the interactions between articulatory and perceptual drives*. PhD dissertation, University of Amsterdam. The Hague: Holland Academic Graphics.
- Boersma, Paul, and Bruce Hayes (2001). Empirical tests of the Gradual Learning Algorithm. *Linguistic Inquiry* 32, 45-86.
- Crasborn, Onno (2001). *Phonetic implementation of phonological categories in Sign Language of the Netherlands*. PhD dissertation, Leiden University. Utrecht: Landelijke Onderzoeksschool Taalwetenschap.
- Escudero, Paola, and Paul Boersma (2001). Modelling the perceptual development of phonological contrast with Optimality Theory and the Gradual Learning Algorithm. To appear in *Proceedings of the 25th Penn Linguistics Colloquium*, Rutgers Optimality Archive 439 <http://romansens.edu>
- Escudero, Paola, and Paul Boersma (2002). The subset problem in L2 perceptual development: Multiple-category assimilation by Dutch learners of Spanish. In *Proceedings of the 20th Boston University Conference on Language Development*, 208-219. Somerville: Cascadia.
- All production and perception data, simulation scripts, and most papers are available at <http://www.fon.hum.uva.nl/paul/p2b/>