Phonemic and phonetic contrast in small vowel inventories

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Phonemic and phonetic contrast

- The theme of contrast runs through much current work in phonology.
- However, when we talk about contrast, we're talking about two distinct things:

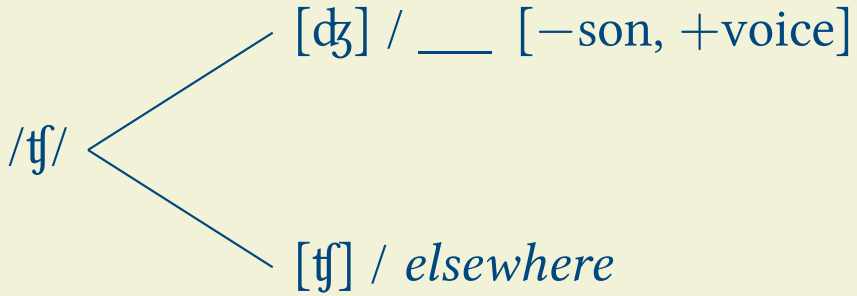
  Phonemic contrast: The potential for phonological units to signal lexical (or structural) differences

  Phonetic contrast: Concrete articulatory, acoustic, and especially auditory differences between sounds

Phonemic and phonetic contrast

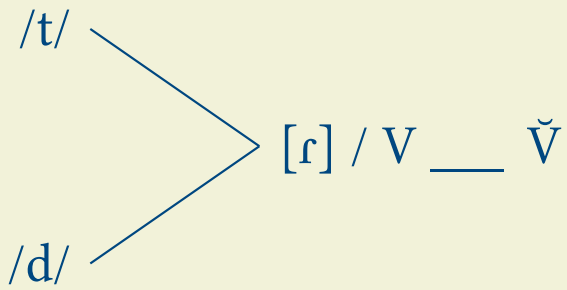
- Phonemic and phonetic contrast are logically independent:
  - Phonetic contrast without phonemic contrast: Allophony

(1) Russian:



  - Phonemic contrast without phonetic contrast: Neutralization

(2) North American English:



Two components of the 'Toronto School' approach to phonemic contrast:

- Why phonemic contrast matters: The Contrastivist Hypothesis
- How to identify it: The Contrastive Hierarchy

The Contrastivist Hypothesis:

Strong version

"The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another."

(Hall 2007a; Dresher 2009)

Weaker version

Some phonological processes operate only on contrastive features.

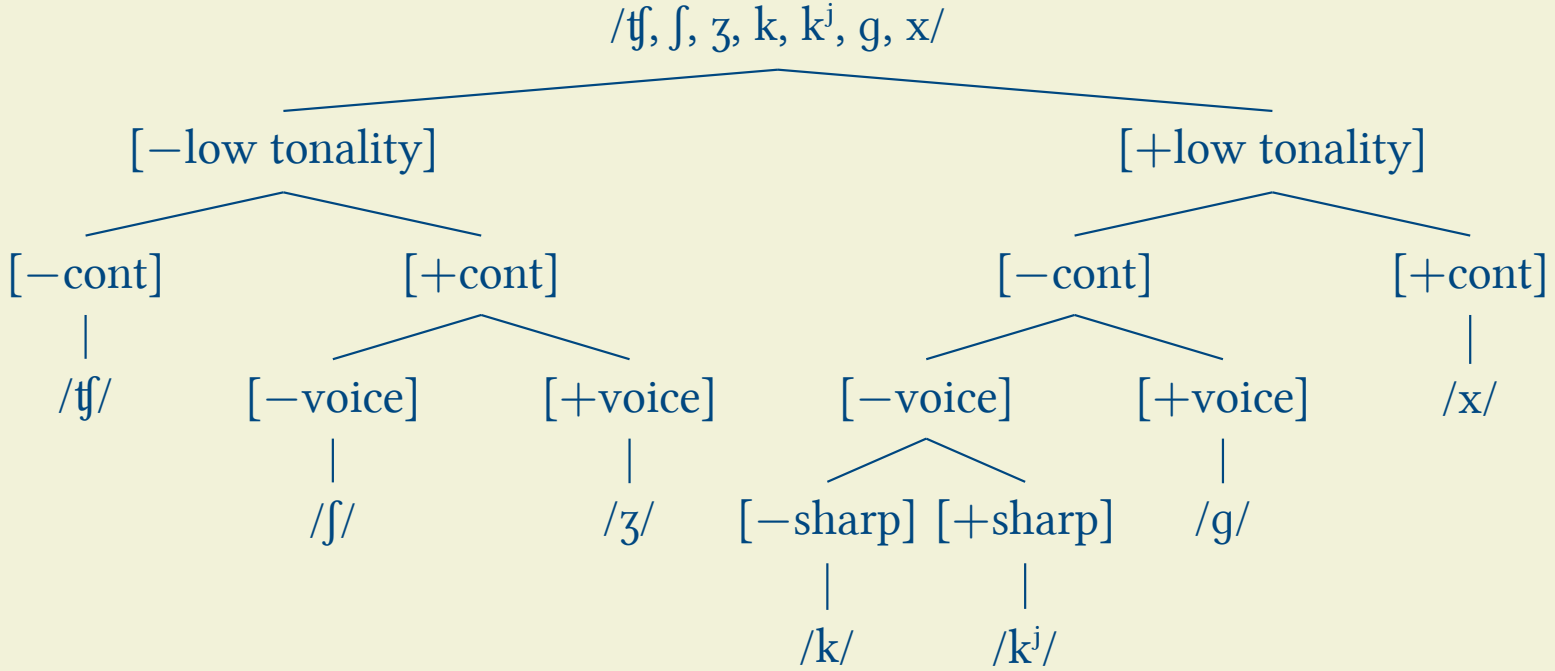
(Archangeli 1988; Nevins 2004; Calabrese 2005)

Phonemic and phonetic contrast

Phonemic contrast: The Contrastive Hierarchy

The Contrastive Hierarchy (Cherry et al. 1953; Jakobson & Halle 1956; Halle 1959; Dresher et al. 1994):

- Features successively divide the phonemic inventory.
- A feature is assigned only if it makes a non-vacuous division.
- Partial hierarchy for Russian consonants (Halle 1959):



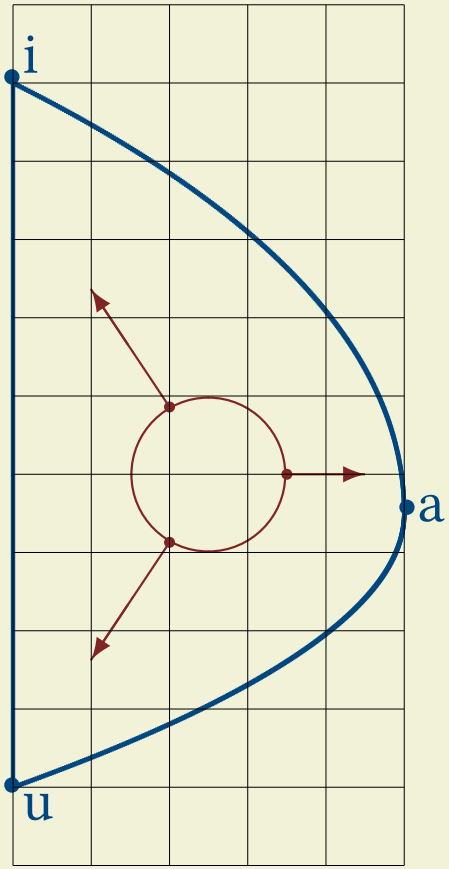
Successive Division Algorithm (SDA; Dresher 2009: §2.3):

1. Begin with no feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.
2. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets as the feature allows for.
3. Repeat step (2) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

The functionalist view of contrast focuses on phonetic contrast (but does so because phonetic contrast serves the functional purpose of realizing phonemic contrasts):

> "[A]ny phonological constraints motivated by perceptual factors should be constraints on contrasts, such as the contrast between a back unrounded vowel and a back rounded vowel, not constraints on individual sounds, such as a back unrounded vowel." —Flemming (2004)

Liljencrants & Lindblom (1972): Vowels disperse through the available space



x = F1 frequency; y = F2 and F3 frequencies

Phonemic and phonetic contrast

Phonetic contrast

OT approaches involve competition among three types of constraints:

- Constraints requiring the existence of surface contrasts:
  - MaximizeContrasts (Flemming 2002)
  - nWords (Ní Chiosáin & Padgett 1997, 2001)
  - *Merge (Padgett 2003)
  - $\mathcal{F}$aithfulness constraints (Sanders 2003)
- Constraints requiring contrasts to be robust:
  - MinDist (Flemming 2002)
  - Contrast (Ní Chiosáin & Padgett 1997)
  - Space (Ní Chiosáin & Padgett 2001; Padgett 2003)
  - $\mathcal{D}$ispersion constraints (Sanders 2003)
- Constraints against effortful (or marked) surface forms:
  - Lazy (Kirchner 1997)
  - MinimizeEffort (Flemming 2002)

English VOT contrasts in medial position (*ogre* vs. *ochre*), adapted from Flemming (2002):

	MinDist =VOT:2	Maximize Contrasts	*Asp.	MinDist =VOT:3
☞ [ogɚ] [okɚ]		✓✓		*
[ogɚ] [ok^{h}ɚ]		✓✓	*!	
[o̥gɚ] [ok^{h}ɚ]		✓✓	*!	*
[ogɚ]		✓!		
[o̥gɚ] [okɚ]	*!	✓✓		*
[ogɚ] [o̥gɚ] [okɚ]	*!*	✓✓✓		***
[ogɚ] [o̥gɚ] [okɚ] [ok^{h}ɚ]	*!**	✓✓✓✓	*	*****

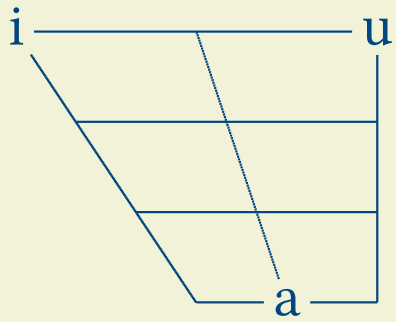
Small vowel inventories

Two triangles

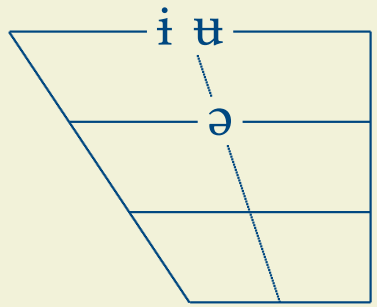
- A familiar observation: (3a) is widely attested; (3b) is not attested at all.

(3) Triangular three-vowel inventories

a. Common



b. Unattested



- Why?
- The Dispersion Theory answer: (3a) is functionally preferable.

Small vowel inventories

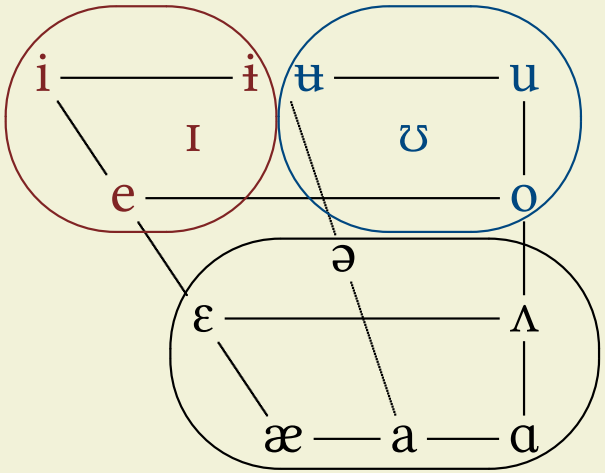
Three reasons

- This talk: A combination of three factors:
  1. Phonological: Minimal representation of contrast
  2. Phonetic: Enhancement of contrastive features
  3. Metalinguistic: Our biases in transcription

Small vowel inventories

Three reasons: The metalinguistic reason

- The phonetic range of a vowel depends in part on what it contrasts with—vowels in a sparser system exhibit wider variation (Manuel 1990; Rice 1995; Dyck 1995).
- A vowel inventory we transcribe as /i, a, u/ might have realizations along these lines:



- We transcribe it as /i, a, u/ rather than /ɨ, ə, ʉ/ at least in part as a matter of convention and convenience—we prefer idealized representations with simpler symbols (see Ladd 2009).

Small vowel inventories

Three reasons: The phonetic reason

- Phonetic enhancement (Stevens et al. 1986; Stevens & Keyser 1989): Perceptually less salient ('secondary') features tend to be marshalled in ways that reinforce the phonetic correlates of 'primary' features.
- Adapted to the TSC framework: Redundant features tend to be marshalled in ways that reinforce the phonetic correlates of contrastive features.
- Phonetic implementation of underspecified phonological representations...
  - ...varies both by language and by syntagmatic context, but...
  - ...generally involves at least some degree of enhancement of specified (i.e., contrastive) features, and...
  - ...is at any rate constrained not to contradict specified features.

Small vowel inventories

Three reasons: The phonological reason

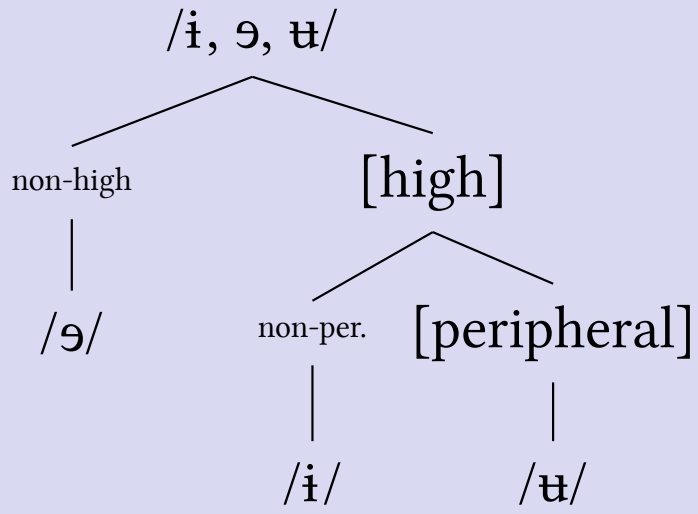
- Phonological representations based on the SDA contain only contrastive features.
- Enhancement of any specified feature therefore necessarily enhances (some) contrast.
- Under this view, there is a division of labour that eliminates any need for explicit comparisons between segments:
  - The SDA determines whether a feature serves to distinguish (sets of) segments.
  - Enhancement amplifies the phonetic realization of contrastive features.
- The SDA simply doesn't permit segments to be explicitly specified as being excessively similar to one another.

Small vowel inventories

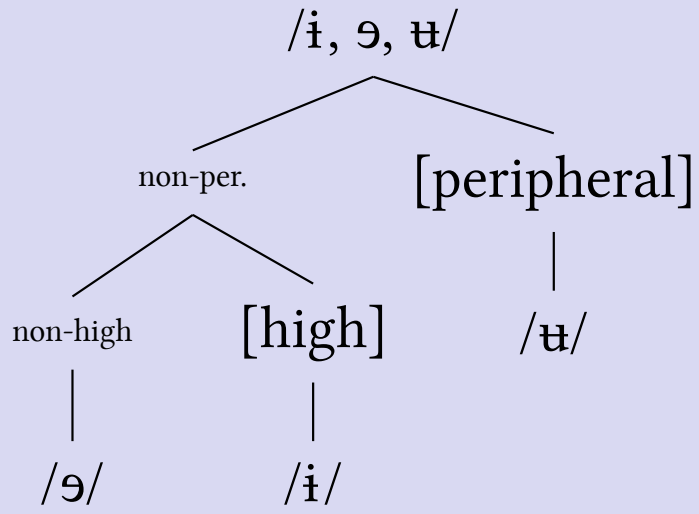
Ruling out */ɨ, ɘ, ʉ/

- Consider what happens when we assign features to the inventory */ɨ, ɘ, ʉ/.
- The only contrasts here to mark are height and rounding.

[high] ≫ [peripheral]



[peripheral] ≫ [high]

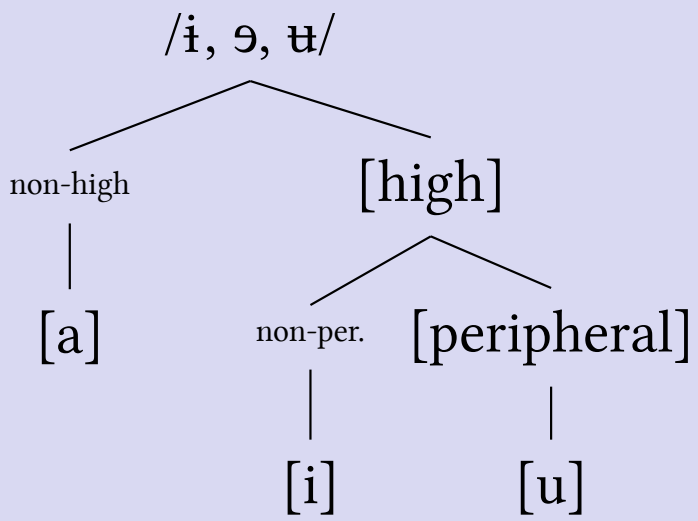


Small vowel inventories

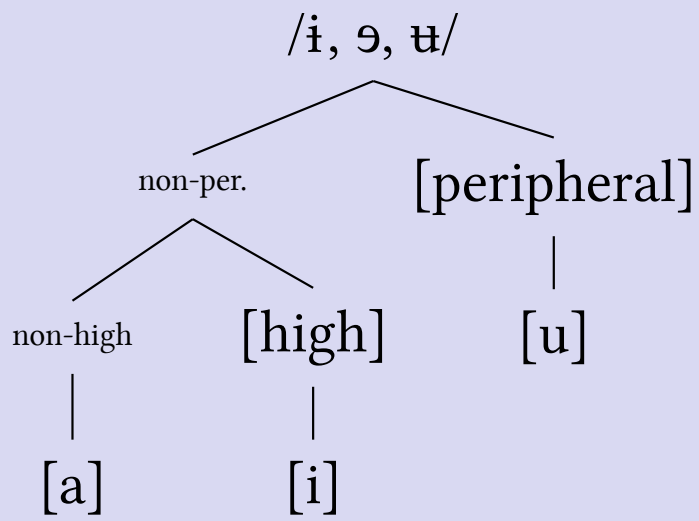
Ruling out */ɨ, ɘ, ʉ/

- Each of these sets of representations is equally consistent with /i, a, u/.
- Natural enhancements:
  - Realize contrastively non-high vowels as low.
  - Realize contrastively [peripheral] vowels as both back and rounded.
  - Realize contrastively non-peripheral vowels as unrounded.

[high] ≫ [peripheral]



[peripheral] ≫ [high]

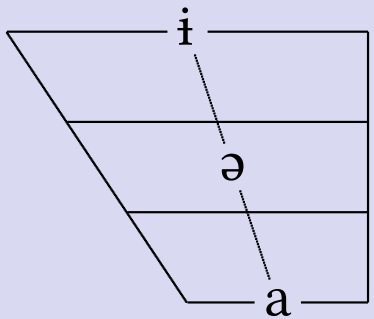


Small vowel inventories

Linear inventories

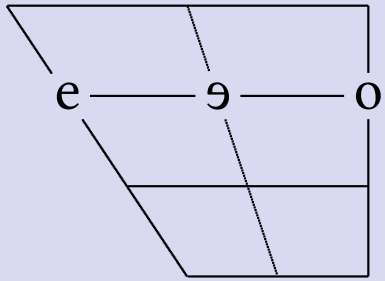
- Under this approach, there is no need for constraints that explicitly evaluate sets of forms for phonetic contrast.
- Are there also empirical advantages? A test: linear inventories

Vertical inventory



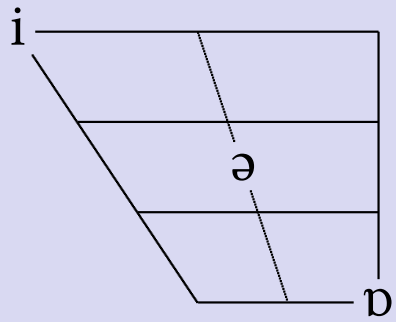
Kabardian, Wosera

Horizontal inventory



unattested

Diagonal inventory



unattested

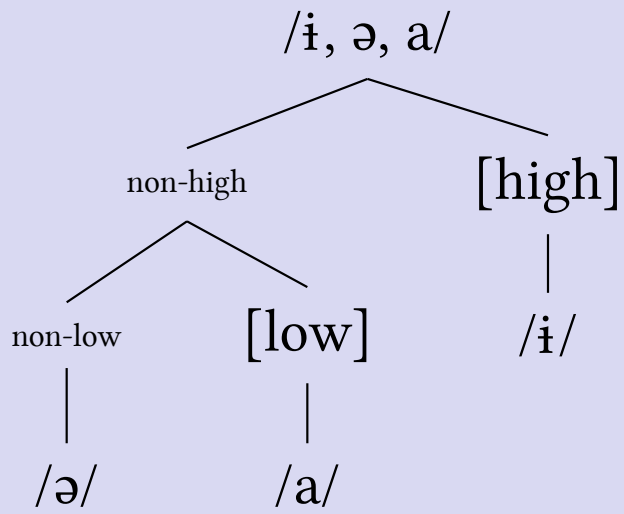
- This is unexpected from the perspective of dispersion—in particular, */i, ə, ɒ/ makes better use of the available space than /ɨ, ə, a/.

Small vowel inventories

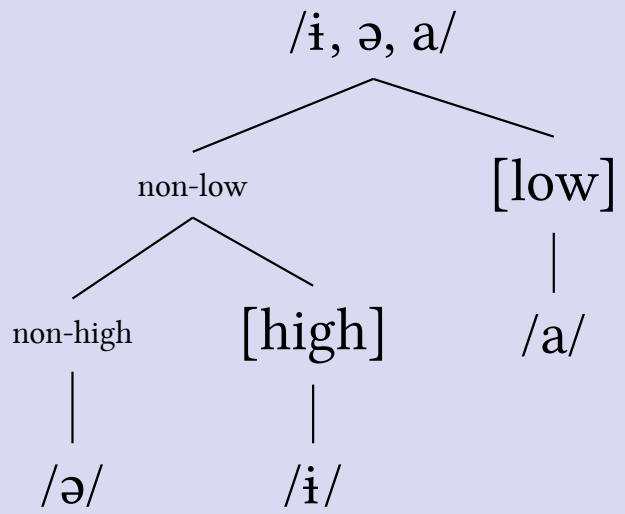
Linear inventories: Vertical /ɨ, ə, a/

- For the vertical inventory /ɨ, ə, a/, the only possible contrasts are height contrasts, and the order of cuts is essentially irrelevant:

[high] ≫ [low]



[low] ≫ [high]



Small vowel inventories

Linear inventories: Vertical /ɨ, ə, a/

/ɨ/	[high]
/ə/	
/a/	[low]

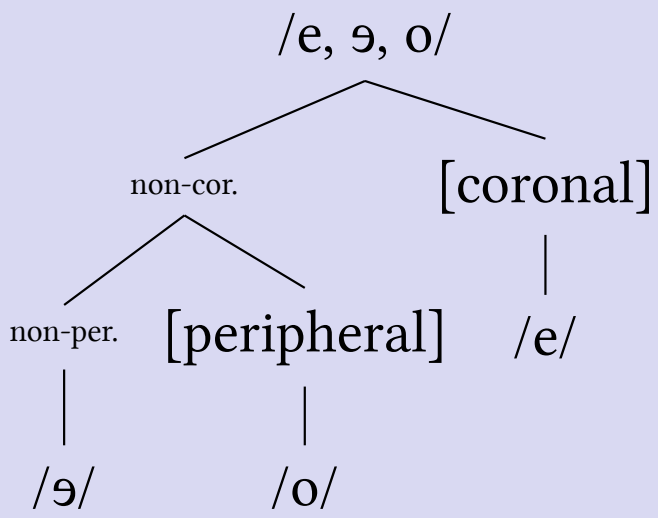
- Additional phonetic differences in place/rounding could increase dispersion, but would not enhance the phonemic height contrasts.
- Instead, what we find is contextually determined allophonic variation in place/rounding.
- Kabardian vowel+glide coalescence: /əj/ → [eː], /əw/ → [oː], /ɨj/ → [iː], /ɨw/ → [uː], etc. (see, e.g., Gordon & Applebaum 2006)

Small vowel inventories

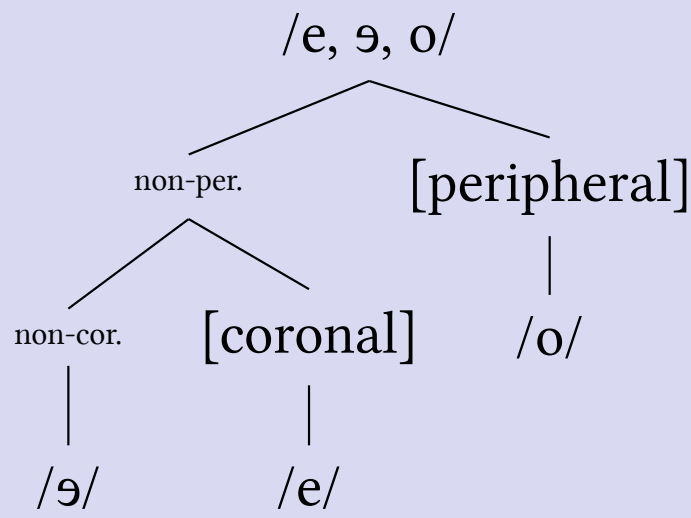
Linear inventories: Horizontal */e, ɘ, o/

- What about a horizontal inventory like */e, ɘ, o/?
- For simplicity, assume there are only two vowel place features, [coronal] and [peripheral] (Rice 1995).
- The two possibilities for */e, ɘ, o/ are, in effect, a rotated version of what we saw for /ɨ, ə, a/:

[coronal] ≫ [peripheral]



[peripheral] ≫ [coronal]



Small vowel inventories

Linear inventories: Horizontal */e, ɘ, o/

[coronal]		[peripheral]
e	ɘ	o

- Like the representations assignable to */i, ɘ, ʉ/, and unlike those assigned to /i, ə, a/, these features could also represent /i, a, u/.
- But *would* they be realized as /i, a, u/?
- Height contrasts are not obviously enhanced by place, but place contrasts can perhaps be enhanced by height.
- Because the vowel space is wider at the top than at the bottom, [i] is 'more coronal' than [e] or [æ], and [u] is 'more peripheral' than [o] or [ɒ].
- More generally, the presence of a particular stricture at a particular place is enhanced by increasing the degree of stricture (and the contrastive absence of coronal and peripheral strictures is enhanced by having minimal stricture).

Small vowel inventories

Linear inventories: Diagonal */i, ə, ɒ/

- What are the possible specifications for the unattested diagonal inventory */i, ə, ɒ/?
- Using only height features produces specifications equivalent to /ɨ, ə, a/:

[high], [low]

i	[high]
ə	
ɒ	[low]

Small vowel inventories

Linear inventories: Diagonal */i, ə, ɒ/

- Using only place features produces specifications equivalent to */e, ə, o/, and thus non-distinct from /i, a, u/:

[coronal], [peripheral]

[coronal]		[peripheral]
i		
	ə	
		ɒ

Small vowel inventories

Linear inventories: Diagonal */i, ə, ɒ/

- If we combine place and height features, then we'll need either [high] and [peripheral] or [low] and [coronal], and scope potentially matters:

[low] ≫ [coronal]

	[cor]	
	i	ə
[low]	ɒ	

Non-distinct from /i, a, u/

[coronal] ≫ [low]

[cor]	
i	ə
ɒ	[low]

Non-distinct from /i, a, u/

Small vowel inventories

Linear inventories: Diagonal */i, ə, ɒ/

[peripheral] ≫ [high]

	[per]
[high] i	
ə	ɒ

Non-distinct from /i, a, u/

[high] ≫ [peripheral]

[high] i	
ə	ɒ
	[per]

Distinct from /i, a, u/

- [Peripheral] ≫ [high] and [high] ≫ [peripheral] yield the same specifications: /i/ is [high], /ɒ/ is [peripheral], and /ə/ is neither.
- However, there is a difference: with [high] ≫ [peripheral], /ɒ/ is contrastively non-high.
- If we assume that phonetic enhancement cannot override contrastively absent features (or contrastive negative values of binary features), /ɒ/ cannot be realized as /u/ here.
- However, these specifications are non-distinct from /i, a, o/, which is attested as the vowel quality inventory of Mikasuki (Sedlak 1969, cited in Liljencrants & Lindblom 1972: 845).

Evaluation

Contrast+enhancement vs. dispersion

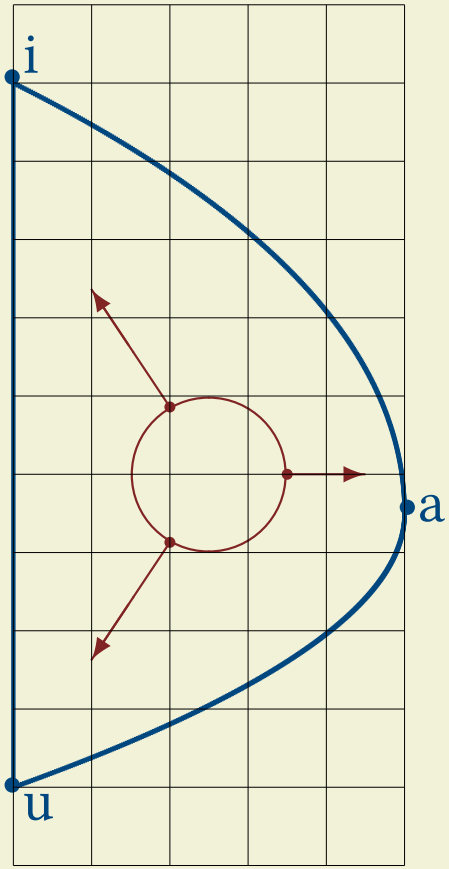
- How does the approach presented here compare with Dispersion Theory?
- Flemming (2004) says that Dispersion predicts /ɨ, ə, a/:

"Crucially there are no vertical vowel inventories containing invariant [i] or [u], vowels which are ubiquitous in non-vertical inventories. That is, there are no vowel inventories such as [i, e, a] or [u, o, a].
"This pattern makes perfect sense in terms of constraints on the distinctiveness on contrasts: as already discussed central vowels are not problematic in themselves, it is the contrast between front and central or back and central vowels which is marked (*i-ɨ, *ɨ-u ≫ *i-u). In the absence of such F2-based contrasts, distinctiveness in F2 becomes irrelevant, and minimization of effort becomes the key factor governing vowel backness" (Flemming 2004).

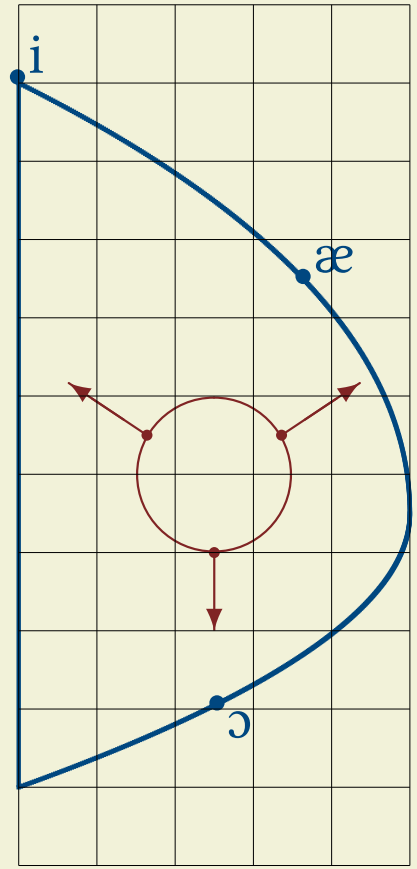
- But how would we know, given an input like /i, ə, ɒ/, whether the contrasts are F1- or F2-based? We need a contrastive hierarchy.

Evaluation

Contrast+enhancement vs. dispersion



- Liljencrants & Lindblom's approach has more in common with the contrast+enhancement model than may be immediately obvious.
- They achieve dispersion by having vowels repel one another from starting positions on the circumference of a circle in the middle of the vowel space.
- The choice of starting positions can make a difference in where the vowels end up (Hall 2007a: §4.2.1).



Evaluation

Contrast+enhancement vs. dispersion

- Liljencrants & Lindblom's starting positions are analogous to feature specifications, which are then enhanced by the outward movement of the vowels.
- One drawback is that their approach has no counterpart to a fully unspecified vowel—each vowel is on the circumference of the starting circle, not in the middle.
- As a consequence, their model undergenerates /ə/ in inventories in general.

Evaluation

Overgeneration?

- Are there unattested inventories to which the SDA can assign features that would distinguish them from attested inventories?
- The short answer: Yes, especially in larger inventories where more contrasts can be marked.
- An unlikely three-vowel inventory:

[low] ≫ [coronal]

	ɨ	
[low]	æ	ɒ
	[cor]	

Evaluation

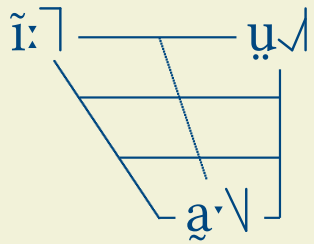
Overgeneration?

- In general, nothing in the SDA disallows a system with more low vowels than high vowels.
- Some versions of Dispersion have the opposite problem—Liljencrants & Lindblom's program generates some inventories with five high vowels and only two low ones, and fails to predict the existence of more symmetrical systems.
- An answer to the problem might come from the feature system, or from the diachronic influence of phonetics.
- One possibility that might be relevant for */ɨ, æ, ɒ/ in particular would be to say that features mark only the dimension and direction of contrast, not the specific borders of phonetic categories.
- E.g., if there is only one contrastive height feature in a system, it isn't as specific as '[high]' or '[low].'
- That makes */ɨ, æ, ɒ/ perhaps not so different from Mikasuki /i, ,a, o/.

Evaluation

Too much contrast?

- Hall (2007b) suggests that the SDA also rules out unattested inventories that involve phonetic contrast along too many dimensions.



- David Odden (p.c.) points out that such additional dimensions of contrast are used in vowel inventories.
- To the extent that we find consistency in phenomena such as inherent F_0 (e.g., Whalen & Levitt 1995) and inherent duration (e.g., Neweklowsky 1975), we can expect these additional dimensions to be used as enhancements of (e.g.) height contrasts (or vice versa).

Evaluation

Too much contrast?

- Where we clearly do want to rule out superfluous dimensions of contrast is in consonant inventories.
- Ohala (1980), quoted in Lindblom & Maddieson (1988), argues that if vowel-like dispersion were applied to consonant inventories...

> [...] we should undoubtedly reach the patently false prediction that a seven-consonant system should include something like the following set:
>
> [ɗ kʼ ʦ ɬ m r ɻ]

- The SDA cannot assign representations to */ɗ, kʼ, ʦ, ɬ, m, r, |/ that would, e.g., mark /ɬ/ as being necessarily both a fricative and a lateral.
- Redundant properties that are not enhancements of contrastive features are not ruled out, but also not specifically expected.

Conclusions

- The SDA in combination with enhancement gives us a way of deriving the effects of dispersion without resorting to explicit comparison of forms.
- This model accounts for some typological patterns in three-vowel inventories that are unexpected under a Dispersion approach—in particular, the absence of horizontal and diagonal linear inventories.
- It also gives us a division of labour between phonology and phonetics.

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