DISPERSENESS WITHOUT DISPERSION

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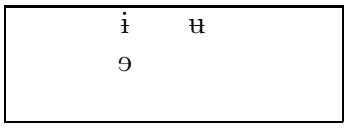
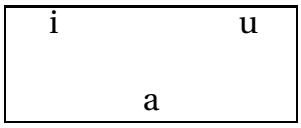
GLOW XXX – UiT – 11 April 2007
The Structure of Segment Inventories

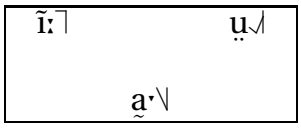
1. INTRODUCTION

Three three-vowel inventories:

(1)

a. 

b. 

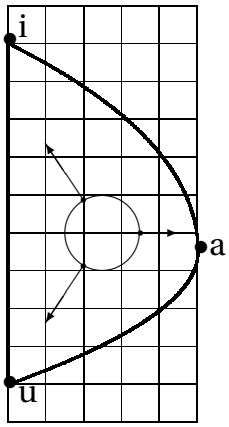
c. 

- A much remarked-upon fact: (1b) is preferred over (1a).
  There is a tendency toward maximization of auditory distinctness.
- A less remarked-upon, but no less well-known fact: (1b) is preferred over (1c).
  Maximization of distinctness tends to occur only along a limited number of dimensions.

Dispersion Theory:

- Liljencrants and Lindblom (1972) model vowels as particles that repel one another and thereby move toward the edges of the available acoustic space.

(2) Dispersion of vowels in Liljencrants and Lindblom's model:



$x =$ F1 frequency; $y =$ F2 and F3 frequencies

- More recent work in the framework of Optimality Theory (e.g., Flemming 2002; Padgett 1997; Sanders 2003) derives the generalizations above from interactions among constraints.

1. I am grateful to Elan Dresher, Keren Rice, Elizabeth Cowper, Sharon Inkelas, and Peter Avery for their helpful comments on the work that forms the basis for this talk, and to the University of Toronto and Universitetet i Tromsø for making it possible for me to present it here.

Constraints formalize tradeoffs between:

- robustness of contrasts *vs.* number of contrasts
- robustness of contrasts *vs.* articulatory effort
- robustness of contrasts *vs.* faithfulness

An example from Sanders (2003: 28): $\mathcal{D}$ispersion constraints *vs.* $\mathcal{F}$aithfulness constraints in an inventory with three high vowels:

(3)

	i y ɨ ɯ u	$\mathcal{D}_1$-color	$\mathcal{F}$-color	$\mathcal{D}_2$-color	$\mathcal{D}_3$-color
a.	i y ɯ u	*!**	*	***	*****
b.	i y u	*!	**	*	**
c.	i ɯ u	*!	**	*	**
☞ d.	i ɨ u		**	**	**
e.	i ɯ		***!		*
f.	i u		***!		
g.	ɨ		***!*		

In an OT implementation of Dispersion Theory, (1a) is penalized by constraints that mandate auditory or acoustic distance between contrasting segments, and (1c) is penalized by constraints against markedness or effort.

This talk:

- The preference for inventories like (1b) can be derived without recourse to explicit comparisons between segments from the following independently motivated devices:
  - **Contrastive specification:** Phonological representations contain only those features that are necessary to distinguish the phonemes of the underlying inventory.
  - **Phonetic enhancement:** Phonetic implementation of segments enhances the auditory salience of their phonological features (Stevens, Keyser, and Kawasaki 1986; Stevens and Keyser 1989).

2. CONTRASTIVE SPECIFICATION

The particular implementation of contrastive specification I adopt is the Successive Division Algorithm of Dresher (2003), which has its basis in the contrastive hierarchy of Jakobson and Halle (1956) and the procedure used by Cherry, Halle, and Jakobson (1953) in measuring the information content of phonemes.

The Successive Division Algorithm (SDA) operates as in (4), assigning features only when they serve to make a distinction between two phonemes or sets of phonemes:

(4) Successive Division Algorithm (binary version, adapted from Dresher (2003: 56):
   a. The input to the algorithm is an inventory I of segments that are not yet featurally distinct from one another.
   b. If I is found to contain more than one phoneme, then it is divided into two non-empty subinventories that differ in some property representable by a binary feature F. One subinventory I^+ is assigned the feature value $[+F]$; its complement I^- is assigned the value $[-F]$.
   c. I^+ and I^- are then treated as input to the algorithm. The process continues until all phonemes are featurally distinct, which is trivially the case when the input inventory I contains only one phoneme.

The SDA guarantees that:

- Any inventory can be assigned features that suffice to distinguish its phonemes.
- No feature will be assigned to any segment unless it is contrastive.

Because the order in which features are used to make divisions is not stipulated, there is room for cross-linguistic variation in this respect: two languages with superficially similar phonemic inventories may represent them quite differently.

For example, the inventory in (1b) can be divided in eight ways by [±high], [±low], [±back], and [±round], depending on the relative scope of the features:

(5) a. hi > bk (rd and lo redundant): i = [+hi, −bk]; u = [+hi, +bk]; a = [−hi]
   b. hi > rd (bk and lo redundant): i = [+hi, −rd]; u = [+hi, +rd]; a = [−hi]
   c. bk > hi (rd and lo redundant): i = [−bk]; u = [+bk, +hi]; a = [+bk, −hi]
   d. rd > hi (bk and lo redundant): i = [−rd, +hi]; u = [+rd]; a = [−rd, −hi]
   e. lo > bk (hi and rd redundant): i = [−lo, −bk]; u = [−lo, +bk]; a = [+lo]
   f. lo > rd (hi and bk redundant): i = [−lo, −rd]; u = [−lo, +rd]; a = [+lo]
   g. bk > lo (hi and rd redundant): i = [−bk]; u = [+bk, −lo]; a = [+bk, +lo]
   h. rd > lo (hi and bk redundant): i = [−rd, −lo]; u = [+rd]; a = [−rd, +lo]

(6) a. (5b): [±high] > [±round] > [±back], [±low]

	[−round]	[+round]
[+high]	i	u
[−high]	a	

   b. (5d): [±round] > [±high] > [±back], [±low]

	[−round]	[+round]
[+high]	i	u
[−high]	a	

3. PHONETIC ENHANCEMENT

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.

For example:

- A vowel that is contrastively [−high] may be enhanced by being realized as [+low], as long as it is not also specified as [−low].
- A vowel that is contrastively [+round] may be enhanced by being realized as [+back], as long as it is not also specified as [−back].

Enhancement varies…

- …according to language—e.g., Japanese and Czech each contrast two high vowels, /i/ and /u/, but Czech realizes them as [i] and [u], Japanese as [i] and [ɯ].[2]
- …according to environment—e.g., we generally find greater enhancement of vowel features in stressed syllables.

4. CONTRASTIVE SPECIFICATION + PHONETIC ENHANCEMENT

It makes sense to view underspecified segments as **spaces, not points**.

Rice (1995); Dyck (1995): The contrasts a segment enters into determine the limits of the space within which its phonetic realization ranges.

(7) Phonetic realization of vowels unspecified for place

a. High vowels in Gonja:

(Rice 1995: 103)

/i/ = [i, ɪ, ɨ]	/u/
	|
	Peripheral

b. High vowels in Yimas:

(Rice 1995: 107)

/i/	/ɨ/ = [ɨ]	/u/
|		|
Coronal		Peripheral

c. Low vowel in Diyari:

(Rice 1995: 106)

/a/ = [ɛ, æ, ʌ, ɔ, ɑ]

2. See Hirayama (2003) for a contrastivist account of the Japanese vowel system in which /u/ is underlyingly fully underspecified.

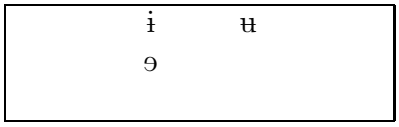
What does this mean for the disperseness of segments?

- Segment-spaces are contiguous. At the phonological level, it doesn't make sense to talk about how far apart the segments are.
- If all specified features are contrastive, then enhancement of specified features is enhancement of contrast. At the phonetic level, segments will tend to be realized in robustly distinct ways.

4.1. INVENTORIES WITH TOO LITTLE CONTRAST

Consider for example how the SDA divides the implausible inventory in (1a), repeated below in (8), using the same features we used for /i a u/.

(8)



The features [±back] and [±low] cannot divide the inventory in (8), so only [±high] and [±round] are relevant. This gives us two possible orders of divisions:

(9) a. hi > rd: ɨ = [+hi, −rd]; ʉ = [+hi, +rd]; ɘ = [−hi]
b. rd > hi: ɨ = [−rd, +hi]; ʉ = [+rd]; ɘ = [−rd, −hi]

(10) a. (9a): [±high] > [±round] > [±back], [±low]

	[−round]	[+round]
[+high]	ɨ	ʉ
[−high]	ɘ	

b. (9b): [±round] > [±high] > [±back], [±low]

	[−round]	[+round]
[+high]	ɨ	ʉ
[−high]	ɘ	

Consequences:

- Using the SDA, it is impossible to assign representations to /ɨ, ɘ, ʉ/ that could not just as easily represent /i, a, u/:
  - (9a)/(10a) is equivalent to (5b)/(6a).
  - (9b)/(10b) is equivalent to (5d)/(6b).
- Applying phonetic enhancement to the representations in (10) will tend to produce /i, a, u/:

- Contrastively [−round] /ɨ/ will tend to be enhanced to [−back] [i].
- Contrastively [+round] /ʉ/ will tend to be enhanced to [+back] [u].
- Contrastively [−high] /ɘ/ will tend to be enhanced to [+low] [a].

Phonologically speaking, the inventory in (6a) is the same as (10a), and (6b) is the same as (10b). What makes these inventories tend to be pronounced (and transcribed!) as /i, a, u/ rather than /ɨ, ɘ, ʉ/ is enhancement.

The sets of feature assignments in (5) are all ambiguous between /i, a, u/ and various less disperse surface realizations, in much the same way that the representations in (9) could all be /i, a, u/.

But this kind of symmetry between disperse and non-disperse implementations does not always apply. In general, an inventory with too little contrast cannot be represented in such a way as to exclude the possibility of greater disperseness, but a more disperse inventory can sometimes be given feature assignments that will rule out a less disperse implementation.

Consider for example the highly implausible obstruent inventory in (11), which consists entirely of coronal plosives:

(11)

[−posterior]		[+posterior]		
[−strident]	[+strident]	[−distributed]	[+distributed]	
t̪	ts	ʈ	c	[−voice]
d̪	dz	ɖ	ɟ	[+voice]

The contrastive features in (11) could be enhanced as follows, yielding the inventory in (12):

- [+continuant] enhances [+strident] segments.
- [+labial] enhances non-strident [−posterior] segments.
- [+dorsal] enhances the feature combination [+posterior, +distributed].

(12)

[−posterior]		[+posterior]		
[−strident]	[+strident]	[−distributed]	[+distributed]	
p	s	ʈ	k	[−voice]
b	z	ɖ	g	[+voice]

The resulting surface inventory could be represented phonologically as in (13), producing a set of representations incompatible with (11).

(13)

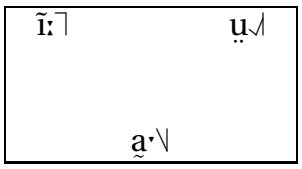
[+labial]	[−labial, −dorsal]		[+dorsal]	
	[+continuant]	[−continuant]		
p	s	ʈ	k	[−voice]
b	z	ɖ	g	[+voice]

Indeed, if children acquiring a phonemic inventory tend to make divisions based on more 'major' or robust features before turning to the more 'minor' ones (Jakobson and Halle 1956; Clements 2003), then we should expect a diachronic tendency away from inventories such as (11) and toward ones such as (13).

4.2. INVENTORIES WITH TOO MUCH CONTRAST

If there is a tendency toward more robust contrasts, what rules out the hyperdistinct inventory in (1c), repeated below in (14)?

(14)



The vowels in (14) differ along several dimensions:

- height
- place
- rounding
- length
- nasality
- phonation type
- tone (height and shape)

The SDA, however, can represent only any two of these dimensions, because it takes only two features to distinguish three vowels.

Moreover, most of the dimensions listed above are orthogonal to one another, and so are not natural candidates for enhancing one another.

(However, we probably need UG to say something about, e.g., the fact that tone seems to be a property of syllables rather than of vowel phonemes.)

5. CONCLUSIONS

The combination of the SDA with phonetic enhancement thus has two significant good results:

a. Because all specified features are contrastive, enhancement of specified features will enhance overall distinctness without recourse to explicit comparison.

b. Because contrasts are always represented by minimal sets of features, both minimally and extravagantly distinctive inventories (such as (1a) and (1c)) will be assigned representations compatible with, and will tend to be realized as, reasonably distinctive inventories (such as (1b)).

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