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The role of similarity in phonology and morphology

Overall 'similarity' of representations = distance between points in multidimensional space is inherent in most work on **perception**.

Categorical Perception: a percept is interpreted as an instance of the nearest category

Liljencrants and Linblom's (1972) **Dispersion Theory**:
vowel inventories maximize Euclidean distance $d(\mathbf{x}_i, \mathbf{x}_j) = \left[\sum_{k=1}^{m} (x_{ij} - x_{jk})^2 \right]^{1/2}$

Repp (1982):
perceptual cues for consonants hold '**trading relations**' (their sum total is what counts)

Kuhl and Iverson (1995):
a phonemic category constitutes a '**perceptual magnet**' (attraction over distance)

Newman, Sawush and Luce (1997):
phoneme identification in a non-word is influenced by **lexical neighborhood** of the non-word

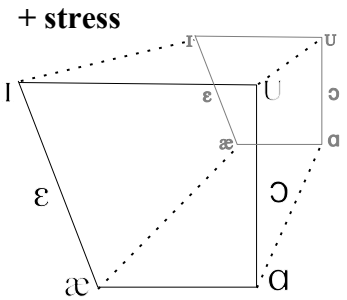
Notion of perceptual distance has entered into perception-based OT phonology

Flemming (1995) incorporates Dispersion Theory into OT

Steriade (1994), (1997): perceptual cues control neutralizations

Steriade's (2001) P-Map: perceptual distances translate into rank of FAITH constraints in OT

Wilson's (2000) 'Targeted Constraints' expressing weakness of contrast yield 'opacity' effects (like derivations)



Q: Is the role of summation and continuous (as opposed to discrete) mathematics limited to phonetics and the phonetics-phonology interface?
A: No. The effects of distance are also present in patterns of allomorphy (morpho-phonology).

Allomorphic changes tend to cluster:
lárynx ⇒ lárynx-es (same stress, same segments)/ *larýng-es* (different stress, different segments)
compáre ⇒ compár-able (same stress, same semantics)/ *cómpar-able* (diff. stress, diff. semantics)

Clustering is symptomatic of the phenomenon called '**Non Derived Environment Blocking**'

A specific change occurs only if some other change has occurred.

(surfacey) Input	Stress change	*CiV*-lengthening
rémedy-able ⇒	remédi-able ⇒	remé꞉di-able
lévy-able		*lé꞉vi-able

Certain allomorphic changes are thus sensitive to other changes: distance.
Distance is also involved in the phenomenon called '**Lexical Conservatism**' (Steriade 1999)

Expected repair neutralizes with independently existing allomorph –a 'neighbor' by definition.

Input		repair induced by ONSET		Independent allomorph
nouv[ɔ] ami	⇒	nouv[ɔ]C$_?$ ...	⇒	nouv[ɛ]l ...

Baayen (2003). Choice of linking element for a new compound in Dutch is only predictable in terms of the **similarity relation** to existing compounds.

schaap- **en** -bout		'leg of mutton'
schaap- -herder		'shepherd'
schaap- **s** -koi		'sheepfold'

Burzio (2002a,b) **Representational Entailments Hypothesis** (REH):

Mental representations of linguistic expressions are sets of entailments.

Entailment matrix for a representation ABC: 1= entailment

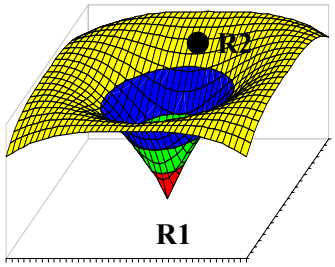
⇒	A	B	C
A	1	1	1
B	1	1	1
C	1	1	1

Each of A, B, C can be phonemes in a sequence, features within a phoneme, or other.

Yields attraction over distance
Entailments violated by ¬C in some R2, given an **R1= A B C**:

Varying the structure of R2:

A⇒C		
B⇒C	A⇒C	
A	A	
B	¬B	
¬C	**¬C**	



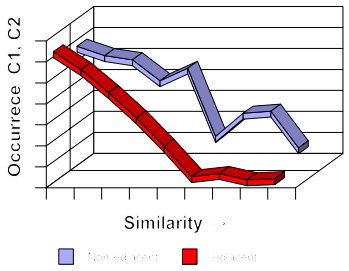
Take-over of OT FAITH constraints ~~IO-FAITH~~ Attraction: Non-Derived Environment Blocking
~~OO-FAITH~~ Attraction: Lexical Conservatism

Attraction also handles:
Syncretism in Morphology
* enhances the similarity relation, yielding neutralization

gli	gli + **lo***	⇒ **glielo**
le	le + **lo***	

Perceptual effects (categorical perception/ perceptual magnet): percept attracted to category
Dispersion Theory: Maximal distance = maximal harmony (minimal attraction)
The REH also yields a theory of **surface-to-surface morphology**. Entailment summation across the lexicon yields subcategorization frames like **-al ⇒ /N __**
.....
Extending attraction by extending the scope of 'similarity':
In a sequence ABC, A and B are sequentially similar, as are B and C.

Empirical evidence:
Frisch et al. (2004): trade-offs between feature-similarity and sequential proximity in **OCP effects in Arabic** (chart based on their Table IV, p. 203).



$\mathbf{C_\alpha V_\alpha}$: Assimilations of Cs to adjacent Vs are common (palatalizations, spirantizations, voicing), and seem to require some independent similarity $C_\beta V_\beta$. E.g. Spanish spirantization: *Cu[β]a/ co[p]a* (same voicing ⇒ same continuancy).

***C_α X V_α**: Comparable long distance assimilations are unattested.
C_α X C_α: Long distance assimilations between Cs are attested, but only under strong similarity: Rose and Walker (2004). Cf. also Vowel harmony, often 'parasitic'.

featural proximity ↑↑	**Generalized Similarity**		**restrictions** ⇨
Max: within Cs or Vs	**Dispersion Theory** (inventories)	LongDist. effects: Rose and Walker	**Syllable Theory**: *VV; *CC
Min: across C, V	no restriction	full inventory	Local Assim./Dissim.
freedom ⇦	Zero: in the same language	Min: in the same sequence	Max: adjacent/ articulatorily local

sequential proximity ➜➜

REH: very powerful in ability to subsume much traditional theoretical machinery, **but** no prediction of which components may cluster, yielding smaller units:
ABC/ AB ¬C = clustering of A, B violates 2 entailments
ABC/ A ¬BC = clustering of A, C violates 2 entailments also

However, while morphemes are clusters of phonemes, by and large there are no discontinuous morphemes, like a hypothetical *in-.....-y*, such that *in-accurac-y* would just mean 'inaccurate'.

REH seems to fail in helping understand the character of 'inventories', or does it?

Scale of units	**Inventory?**	**GS?**
distinctive features	Yes, determined by articulation/ perception	
segments (phonemes)	Yes, not all features combine freely: [+back] ⇒ [+ round]	(y)
bi-phones	Approx.: only homogeneous: diphthongs or C clusters	y
n>2-phones	No	n
morphemes (phonemes + meaning)	Adjacent phonemes: in-, -al, -ment, ...	y
	Non-adjacent k t b but homogeneous for major class (Semitic): u i	y

Burzio (2005, 77-81) offers a crude set of inferential steps to derive as a corollary of REH/ attraction:

the **Binding corollary**: Any two components A, B (of a representation 'X, A, B, Y' that includes them) 'bind' together to the extent that they are similar. That is, the strength of the entailments A⇒ B, B ⇒ A under the REH is determined by the generalized-similarity of A and B.

Note: Similarity also establishes attraction, so that A, B could also undergo either assimilation or dissimilation (whatever further similarity or dissimilarity results will determine the binding effect).

The **binding corollary** thus unravels the ontology of units: there are phonemes, and there are only morphemes of very specific types; there are no diphones, except (approx.) diphthongs and C clusters.

Proof?
A. Wayment (in progress) provides proof in terms of a neural net simulation.

E.g. Analysis of R (round) and B (back) into putative acoustic sub-features as a test case for the more general situation of partial similarity.

	identical			different				
	a1	**a**2	**a**3	**a**4	**a**5	**a**6	**a**7	**a**8
+R	1	1	1	-1	1	-1	-1	-1
~R	-1	-1	-1	-1	-1	1	-1	-1
+B	1	1	1	1	-1	-1	1	-1
~B	-1	-1	-1	-1	-1	-1	-1	1

The REH = Hopfield net: each unit is connected to each of the others. Above entailment matrix = weight matrix
Representation A, B, C = a 'vector' V
Matrix: Outer product (Tensor product) of V with itself: **V** ⊗ **V**

	A	B	C
A	1	1	1
B	1	1	1
C	1	1	1

Applying this now to [round] and [back], putting vowel height aside and assuming that we are dealing only with high vowels, we have:

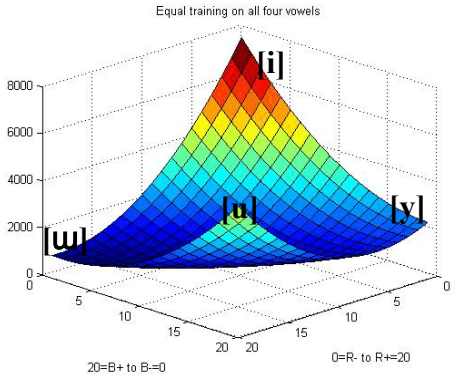
	~B	**+B**
+R	y	u
~R	i	ɯ

Thus, we have two vectors: αR and βB (α, β each varying over +, ~), which co-occur in any one vowel. The Hopfield net implementation of the REH, gives, for each vowel, 4 weight matrices:

αR ⊗ αR	Outer product of αR with itself (each internal component of αR entails the others)
βB ⊗ βB	Outer product of βB with itself (each internal component of βB entails the others)
αR ⊗ βB	Outer product of αR with βB (the vector αR entails the vector βB)
βB ⊗ αR	Outer product of βB with αR(the vector βB entails the vector αR). Same as above.

The REH-based representation of each of the four vowels: the total set of entailments (weight matrix) for an αR co-occurring with a βB, equals the sum of the four weight matrices.

The predicted clustering of backing and rounding would now consist of some **greater harmony** of the sum matrices for **+R**, **+B** (=[u]) and **~R**, **~B** (=[i]) compared with the matrices for the other two vowels.



Indeed:

The proof generalizes to other cases (the specific acoustic features a1-a8 are arbitrary and only serve to implement some degree of similarity/ dissimilarity). Hence: **The ontology of units (phonemes/ morphemes) is inferrable from the binding of subunits under generalized similarity.**

Conclusion: The resources of continuous mathematics, that include the ability to perform summations are no more dispensable in the study of morpho-phonology than they are in the study of perception. Summation is inherent in the notion of distance in multidimensional space, which in turn is critical to understanding a broad range of effects that include: Non-Derived Environment Blocking, Lexical Conservatism, morphological syncretism, and the nature of both segmental inventories and inventories of morphemes.

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