L' Acantatrice Chauve

Loser candidates in SA-OT and speech rate

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Question

Why should we include candidates in the OT candidate set that can win for no hierarchy, and hence, represent no type in the factorial typology?

Proposed answer: they still may play a role.

Namely, in accounting for the speech rate dependent frequencies of alternating forms.

Overview

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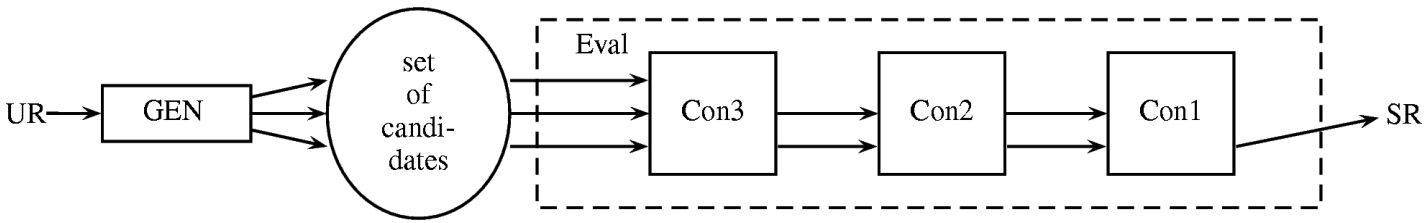
Optimality Theory: an optimisation problem



Candidate w evaluated for constraints $C_N \gg C_{N-1} \gg C_1$:

$$E(w) = \Big(C_N(w), C_{N-1}(w), ..., C_1(w)\Big) \in \mathbb{N}_0^N$$

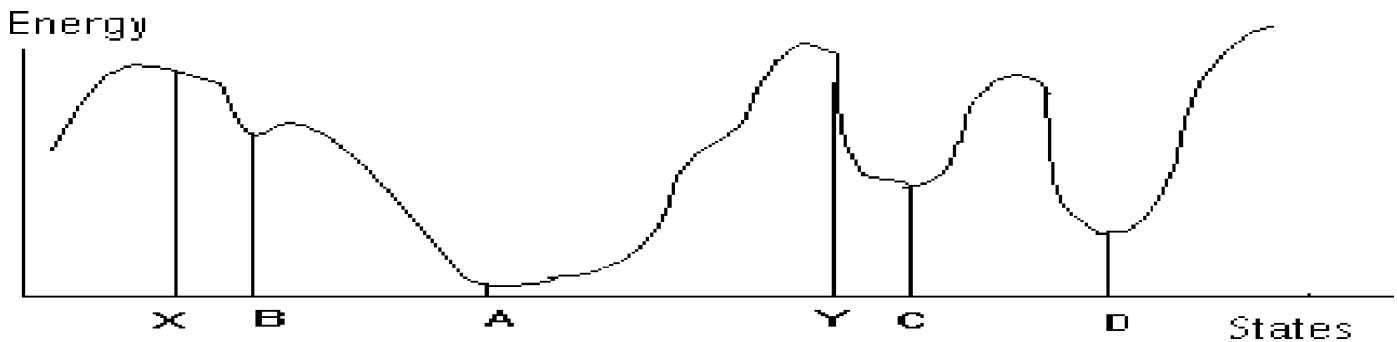
$$SR(\,UR) = \text{argopt}_{w \in Gen(\,UR)} E(w)$$

Optimisation with respect to lexicographic ordering

Simulated Annealing (SA)

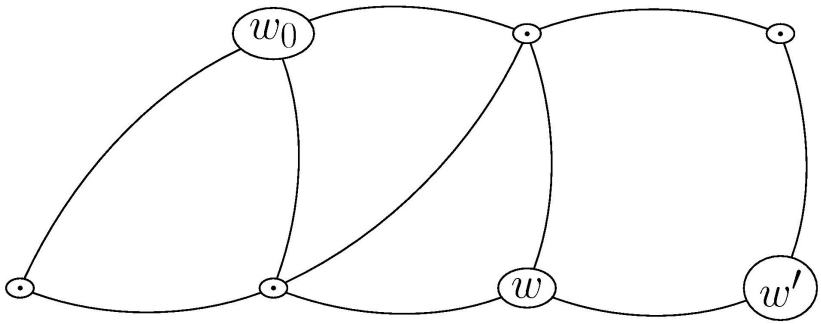
Searching for the *global* minimum of a function

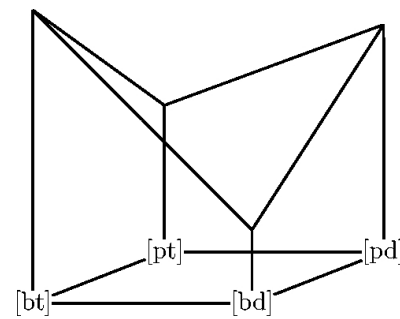
(Widespread algorithm borrowed from statistical physics)



$$P(w \to w') = \begin{cases} 1 & \text{ha } E(w') \leq E(w) \\ e^{-\frac{E(w')-E(w)}{kT}} & \text{ha } E(w') > E(w) \end{cases}$$

OT + SA = SA-OT





- Random walk on the candidate set
- Neighourhood structure (topology, geometry)
- Local optima, into which the algorithm can be stuck
- Precision of the algorithm depends on its speed

The SA-OT algorithm

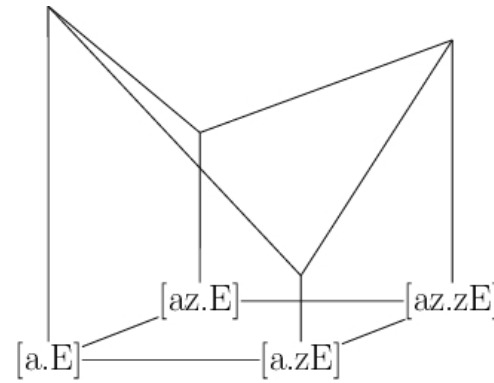
```
w := w_init ;
for K = K_max to K_min step K_step
      for t = t_max to t_min step t_step
            CHOOSE   random w' in Neighbourhood(w) ;
            COMPARE  w' to w:  C := fatal constraint
                               d := C(w') - C(w);
            if d <= 0 then w := w';
            else           w := w' with probability
                       P(C,d;K,t) = 1          , if C < K
                                  = exp(-d/t)  , if C = K
                                  = 0          , if C > K
      end-for
end-for
return w
```

The role of topology

- Introduction of a topology = introduction of local optima
- Only local optima (including the global optimum) returned
- Different speed – different frequencies for the outputs
- Earlier models in SA-OT:
  - Grammatical form = local optimum, which is
  - ... returned with probability $\approx 100\%$ in slow simulation
  - Fast runs: also other local optima = fast speech forms

Not always working

		C_3	C_2	C_1
☞	a.zE			*
∼	az.E		*!	*
	az.zE	*!		
	a.E	*!		**



Both local minima returned with chance 50%.

NB: In SA-OT, the alternating form is not necessarily the second best.

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Article in Hungarian

Two allomorphs: *a* / *az*

az énekesnő	'the soprano'	(1)
a kopasz énekesnő	'the bald soprano'	

What is happening is optimizing the CV structure.

Yet, optimizing also the syllable structure (would) require resyllabification:

a.zénekesnő

Experiment: measuring the rate of resyllabification

Subjects:

- Four female native speakers of standard Hungarian
- Age range: 23-26, mean age: 24.25
- University students from upper-middle class families
- No reported linguistic or other language-related disorder
- From South-East Hungary, but not speakers of dialect

Material (1)

Type (1): minimal pairs of article + noun constructions

az	*ár*	*a*	*zár*
the	price	the	lock

Type (2): article + noun *vs.* single word

az	*úr*	*azúr*
the	lord / master	azure (colour)

Type (3): baseline case, no contrast

az	*asztal*
the	desk / table

Material (2)

- Three tokens of each example type.
- Embedded in short carrier passages: emotionally neutral, natural-sounding, news-like or simple narrative texts.
- Test words or combinations appear in natural and probable positions, neutralizing frequency differences across items.
- Never inserted into clause-initial or clause-final positions, to avoid interaction with sentence prosody.
- Printed separately, white A4 sheets, black, 20-point Times New Roman.

Material (3)

A városban nyitottak egy új bevásárlóközpontot, de az árak olyan magasak voltak, hogy az üzletek fele néhány hónap alatt csődbe ment.

A new shopping mall was opened in the town, but the prices were so high that half of the shops went under within a few months.

Az asztalos gyönyörű ajtókat faragott a kastély fejújításához. Mivel a zárak is rézből voltak, szép régies, patinás hatást sikerült elérni.

The joiner prepared wonderful doors for the renovation of the castle. As even the locks were made of brass, he could create an old, beautiful impression.

Procedure

- Subjects recorded individually in a quiet room.
- Instructed to read out the passages in three different speeds.
- Speed indicated by mechanical metronome (slow: 40, medium: 63, fast: 116). Speed checked by experimenter: if not as required, passage recorded again.
- Initial time to practice. All passages read at slow speed, then all passages read at medium speed, then at fast speed.
- Order of passages randomized before each speed by shuffling the sheets.
- Plantronics microphone, IBM laptop, Praat sound-editing software.

The speaking rate values

The speaking rate values in syll/min for the four subjects at the three speeds:

	slow	medium	fast
Subject 1	256	321	387
Subject 2	275	352	484
Subject 3	245	319	438
Subject 4	303	371	434

Highly significant main effects of Speed [$F(2, 59) = 463.07$, $p < 0.0001$], Subject [$F(3, 59) = 31.085$, $p < 0.0001$] and Speed $\times$ Subject interaction [$F(6, 59) = 8.3532$, $p < 0.0001$].

Results – Type (1): az+V *vs.* a+zV

Length of the pause between the article and the noun in msec:

	az+V slow	az+V medium	az+V fast	a+zV slow	a+zV medium	a+zV fast
Subject 1	32	4	0	0	0	0
Subject 1	2	5	8	0	0	0
Subject 1	24	0	0	2	0	0
Subject 2	18	2	0	0	0	0
Subject 2	82	4	0	0	0	0
Subject 2	40	32	5	0	0	0
Subject 3	66	11	0	0	0	0
Subject 3	30	20	13	0	0	0
Subject 3	7	0	0	0	0	0
Subject 4	63	65	6	12	0	0
Subject 4	20	11	0	0	0	0
Subject 4	5	2	0	0	0	0
$\# < 20$ms	33%	75%	100%	100%	100%	100%

Results

- 0-2 msec: no pause, neighbouring phonemes sound co-articulated
- 3-10 msec: no clear pause is audible, but there is no co-articulation, the material gives the sensation of containing a subtle break
- 10-20/30 msec: a subtle pause, audible to the trained ear or upon attentive listening, lack of co-articulation, sensation of a break
- 20/30- msec: a clear pause, audible even to the untrained ear

- Highly significant main effect of Speed [$F(2, 71) = 7.8$, $p = 0.001$].
- Very highly significant main effect of Example Type (az+V *vs.* a+zV; $F(1, 71) = 23.1$,$p < 0.0001$).
- Significant interaction between Speed and Example Type [$F(2, 71) = 6.6$, $p = 0.003$].

Results – Type (2): az+V *vs.* azV

	az+V slow	az+V medium	az+V fast
Subject 1	21	0	0
Subject 1	32	0	0
Subject 2	9	0	0
Subject 2	57	5	0
Subject 3	0	0	0
Subject 3	63	5	0
Subject 4	22	3	0
Subject 4	51	49	0
$\# < 20$ms	25%	87%	100%

Significant main effect of Speed $[F(2, 47) = 6.7, p = 0.004]$.

The faster the rate of speaking, the more probable it is that the *az* article cliticizes onto the noun and the /z/ resyllabifies.

Allomorph *a*: cliticization is default for any speed.

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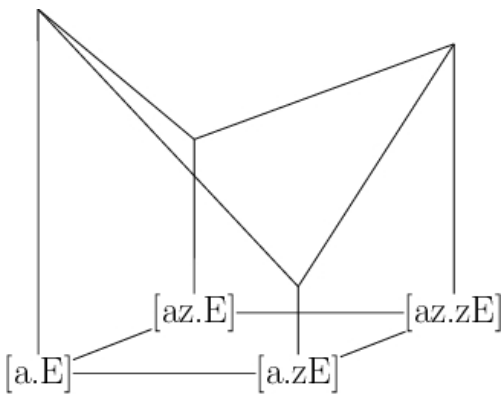
First trial

	/az+E/ / /a+zE/	PARSE	CV	ONS+NOCODA
∼ /	[az.E]	ok / *		**
	[az.zE]		*	*
☞	[a.zE]			
	[a.E]	ok / *	*	*

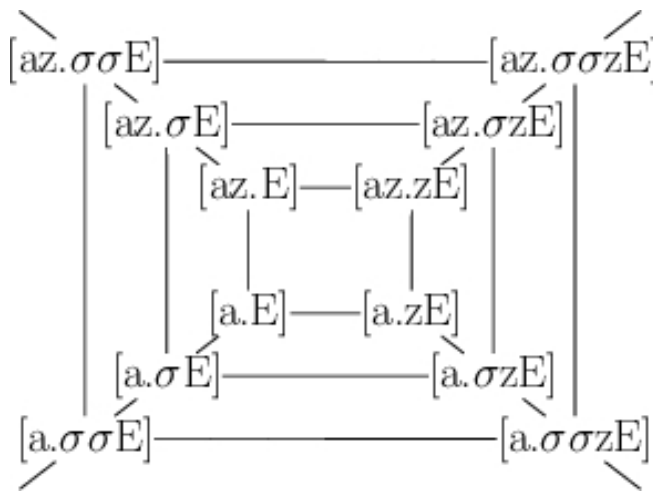


- Neighbourhood structure:
  neighbour iff add or remove one [z]
- [a+zE]: one local optimum
- [az+E]: both local optima
  always returned with 50% chance.

Second trial

Additional candidates: insert syllables in a recursive way.

Neighbourhood structure: neighbour iff either add or remove exactly one [z], or add or remove one syllable.



Second trial

	/az + E/	Dep-σ	CV	Ons+NoCoda
∼	[az.E]			**
	[az.zE]		*	*
☞	[a.zE]			
	[a.E]		*	*
	[az.σ^nE]	n		****
	[az.σ^nzE]	n		**
	[a.σ^nzE]	n		
	[a.σ^nE]	n		**

The two local optima returned with different probabilities that can be tuned using the parameters of the SA-OT algorithm.

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Conclusion: arguing for SA-OT

- No need to generate the entire candidate set.
- Cognitively plausible: simple, few memory.
- Relatively good precision.
  If you speed up algorithms, you pay precision.
- Never winning candidates influence output frequencies.
  Loser candidates in OT needed not only for the mathematical beauty of the model.

Thank you for your attention!