

OTpimality? Interpreting performance errors in SA-OT

Tamás Bíró

Humanities Computing

Center for Language and Cognition Groningen

University of Groningen

`t.s.biro@rug.nl`

Third Workshop on OT and Interpretation
Groningen, November 7, 2008

Overview:

interpreting performance errors

1. Competence-performance
 - (a) Fast speech forms and irregular forms
2. Interpretation in SA-OT
3. Efficient communication in a community of speakers

Overview:

interpreting performance errors

1. Competence-performance
 - (a) Fast speech forms and irregular forms
2. Interpretation in SA-OT
3. Efficient communication in a community of speakers

Proposal: three levels

Level	its product	its model	the product in the model
Competence in narrow sense: static knowledge of the language	grammatical form	standard OT grammar	globally optimal candidate
Dynamic language production process	acceptable or attested forms	SA-OT algorithm	local optima
Performance in its outmost sense	acoustic signal, etc.	(phonetics, pragmatics)	??

Competence vs. performance

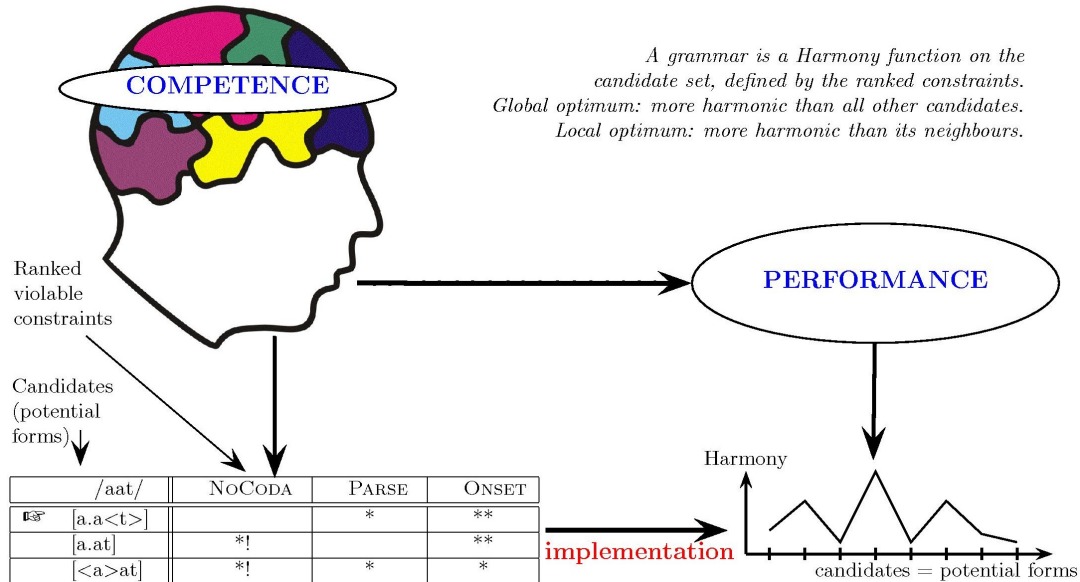
N. Chomsky: “Linguistic theory is concerned primarily with an ideal speaker-listener, ... unaffected by such grammatically irrelevant conditions as memory limitations, distractions, shifts of attention and interest, and errors ... in applying his knowledge of the language in actual performance.” (1965:3)

P. Smolensky: “*competence* can be understood as an idealization of actual behavior—*performance*—in which we have removed the effects of limitations on computational resources: generally speaking, space, time, and precision.” (*The Harmonic Mind*, 2006:I:228.)

Competence = grammar: *function* $input \mapsto correct\ output/parse/struct.\ description$

Performance: *algorithm* that finds it. Or doesn't.

Competence vs. performance



A grammar is a Harmony function on the candidate set, defined by the ranked constraints.
 Global optimum: more harmonic than all other candidates.
 Local optimum: more harmonic than its neighbours.

Optimality Theory

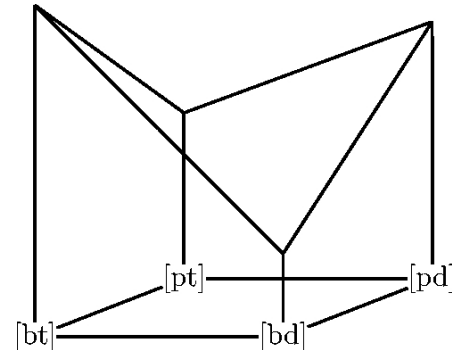
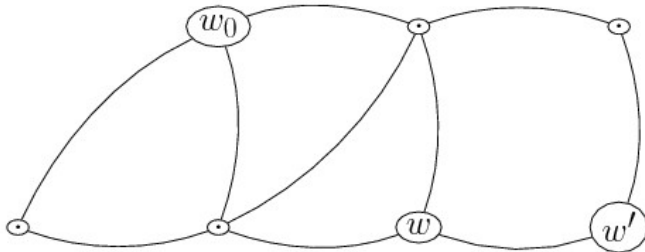
grammar
 competence model
 grammatical form = \mathbb{E}^{opt} (globally) optimal candidate

SA-OT

implementation
 performance model

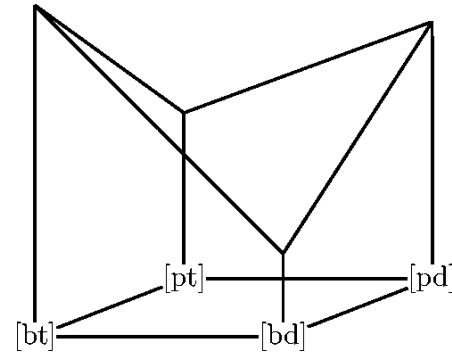
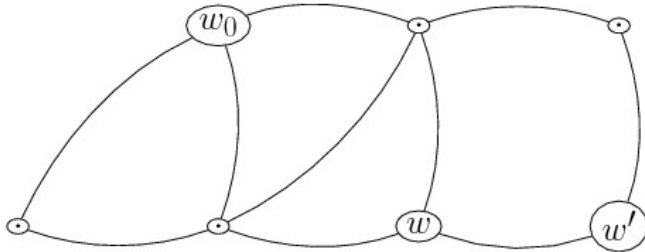
produced forms = globally or locally optimal candidates

Simulated Annealing for OT – general idea



- Neighbourhood structure on the candidate set.
- Landscape's vertical dimension = harmony; random walk.
- If neighbour more optimal: move.
- If less optimal: move in the beginning, don't move later.

Simulated Annealing for OT – general idea



- Neighbourhood structure \rightarrow local optima.
- System stuck in local optima: **performance** errors.
- Precision of the algorithm depends on its speed (!!).
- Many different scenarios.

Errors and irregularities

Divergence between competence and performance:

- ↗ *Grammatical forms* = globally optimal
- ! *Performance errors*: frequency diminishes at slow (careful) production (as in traditional simulated annealing).
- ~ *Irregularities*: frequency does not diminish at slow (careful) production (due to *strict domination*).

Not all forms in a language need be analysed as grammatical!

Adequacy of a performance model

Performance model: an algorithm that realizes (implements) the grammar (*i.e.*, the model of competence), which

- usually finds the form grammatical w.r.t. grammar (\mathcal{G}),
- but also makes the same errors as humans do,
- with a similar frequency
- under various conditions (speech rate, style, etc.).

Moreover, *runtime* and *complexity* of algorithm is plausible.

Example: string-grammar

\mathcal{H} : no0 \gg ass \gg Faith $_{\sigma=0000}$ \gg ni1 \gg ni0 \gg ni2 \gg ni3 \gg nf0
 \gg nf1 \gg nf2 \gg nf3 \gg no3 \gg no2 \gg no1 \gg dis

Globally optimal form: \rightsquigarrow 3333. But 13 local optima: 2222, $\{1,3\}^4$.

Output frequencies for different t_{step} (=inverse speed) values:

<i>output</i>	$t_{step} = 1$	$t_{step} = 0.1$	$t_{step} = 0.01$	$t_{step} = 0.001$
\rightsquigarrow 3333	0.1174 ± 0.0016	0.2074 ± 0.0108	0.2715 ± 0.0077	0.3107 ± 0.0032
\sim 1111	0.1163 ± 0.0021	0.2184 ± 0.0067	0.2821 ± 0.0058	0.3068 ± 0.0058
\sim 2222	0.1153 ± 0.0024	0.2993 ± 0.0092	0.3787 ± 0.0045	0.3602 ± 0.0091
! 1133	0.0453 ± 0.0018	0.0485 ± 0.0038	0.0328 ± 0.0006	0.0105 ± 0.0014
! 3311	0.0436 ± 0.0035	0.0474 ± 0.0054	0.0344 ± 0.0021	0.0114 ± 0.0016
! others	0.5608	0.1776	< 0.0002	–

$L = P = 4$, $T_{max} = 3$, $T_{min} = 0$, $K_{step} = 1$. Each candidate 4 times as w_0 .

Summary of SA-OT

(Without algorithmic details...)

- Universal Gen: also includes neighbourhood structure.
- Therefore notion of *local optimality* introduced.
- Grammatical form: globally optimal.
Attested form: locally optimal (includes globally optimal).

Overview:

interpreting performance errors

1. Competence-performance
 - (a) Fast speech forms and irregular forms
2. Interpretation in SA-OT
3. Efficient communication in a community of speakers

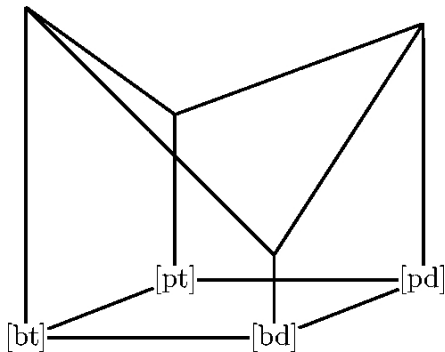
Interpretation in SA-OT?

- Suppose speaker and hearer share hierarchy \mathcal{H} (no learning), beside universal Gen (with neighbourhood structure).
- Observed form: o .
- (Mental) implementation: SA-OT in both directions.
- Interpretation: search for i such that
 - o is local optimum for $\text{Gen}(i)/\mathcal{H}$.
 - Heuristic: probably also global optimum.

Bidirectional SA-OT??

- $\text{Gen}_p(i)$: set of possible forms,
and $\text{Gen}_i(o)$: set of possible meanings.
- \mathcal{H}_p : hierarchy of production constraints
and \mathcal{H}_i : hierarchy of interpretation constraints.
- (i, o) is attested if
 - o is locally optimal for $\text{Gen}_p(i)/\mathcal{H}_p$, and
 - i is locally optimal for $\text{Gen}_i(o)/\mathcal{H}_i$.

The elephant is hitting him: an alternative account?



/ pd /	/him/	C1	C2	C3
pt	e			*
pd	ae		*	...
bd	a			
bt	-		*	...
...@ ^k	...@ ^k	k

Overview:

interpreting performance errors

1. Competence-performance
 - (a) Fast speech forms and irregular forms
2. Interpretation in SA-OT
3. Efficient communication in a community of speakers

Efficient communication full of errors: Performance in a virtual speech community

- Multi-agent simulations:
Agent: competence (OT) + mental computation (SA-OT).
- Communication between two agents: errors affecting communication efficacy?
- New-born agents learn language from elders: correctly?
errors inducing language change?
- Theoretical work (computational and mathematical) +
checking theories against concrete phenomena.

A note on language change

- Iterative learning: change due to imperfect learning, which can also be due to performance errors in production and interpretation.
- Speed vs. precision: evolutionary advantage of efficiency?

Conclusion

- SA-OT: model of performance.
- Performance vs. interpretation?
- Performance errors in interpretation?
- Effect on communication and language change?
- An answer hopefully soon...

Thank you for your attention!