1. Optimality Theory (OT) and Harmonic Grammar (HG)

What is the connection between HG and OT?

Basic building blocks:
- **U**: Set of underlying forms, a non-empty set (universal, cf. the Richness of the Basic Principle).
- **X**: Set of potential candidates/surface forms, a non-empty set (universal).
- **Gen**: the Generator function, a one-to-many mapping $U \rightarrow X$ (postulated to be universal).
- $C_0(x)$: elementary functions ("constraints" - a minimeems), $X \rightarrow N_0$ (universal!), where $k = \ldots \in N$: We suppose that the range of the constraints are the non-negative integers ("number of stars") although there are some exceptions to it in the linguistic literature.

Harmony function:
For hierarchy $C_0 \supseteq C_1 \supseteq \ldots \supseteq C_l$, we have $H_G(x) = \{ -C_0(x), -C_{l-1}(x), \ldots, -C_1(x) \}$. Harmonic Grammar:
For weight system $w_0 \geq w_1 \geq \ldots \geq w_l \geq \ldots \geq w_1$ we have $H_G(x) = \{ -\sum_{i=1}^l w_i \cdot C_i(x) \}$.

Grammatical outputs (surface forms):
The grammatical output corresponding to an input $x \in U$ of optimizes the target function $H$:

$$
\text{SGF}_q(x) = \text{arg max}_{x \in U} H_G(x)
$$

Questions: What is the connection between HG and OT?

2. $q$-Harmonic Grammar ($q$-HG)

To answer this question, a formalism interpolating between HG and OT is introduced:

$q$-Harmonic Grammars: use exponential weights $w_k = q^k$ for some $q > 1$. Hence,

$$
H_G(x) = -\sum_{k=1}^\infty q^{k+1} C_k(x) - \sum_{k=0}^\infty \text{arg max}_{x \in U} H(x)
$$

Notes:
1. Without loss of generality, we can assume on this pointer that constraint indices reflect constraint ranking.
2. More generally, constraint $C_k$ could be assigned rank $r_k$, and then postulate weight $w_k = q^{r_k}$. Presently, however, we set $r_k = k$, in order to implement the OT constraint hierarchy $C_0 \supseteq C_{l-1} \supseteq \ldots \supseteq C_1$ with the least ad hoc decisions. Our results can be applied - mutatis mutandis - to the more general case.

3. Theorem: $q$-Harmonic Grammars have a parameter $q$ that controls the way the harmonic accumulation is performed, which might be prone to error (performance).

4. Performance

Implementation of a grammar with simulated annealing as a model of linguistic performance.
Experiments with a 3-candidate landscape and different taboos (Bíró, 2017).

5. Language acquisition

Word initial consonant cluster simplification in Dutch child speech (collected from CHILDES by Klaus Schinone): $[kl] \rightarrow [kl] \rightarrow [l] \rightarrow [l] \rightarrow [g]$ with significant production differences.

- Child has acquired FARTE $\gg$ NoContOne.

$$
H_k([ni]) = H_k([n]) = q^4 - q^3 - q^2 + q
$$
$$
H_k([li]) = H_k([l]) = q^5 - q^4 + q^3 - q^2 - q
$$

Postulate: $q$ is a function of age, e.g. age $\propto \log(q)$.

6. Summary and “concluding hypotheses”

OT or HG? Bíró (2017). $q$-HG with a higher $q$ - an HG closer to OT - is more prone to errors, but is faster to compute. Hence, in certain domains (in certain domains of certain languages?), grammars prefer a higher $q$ (removing cumulativity effects), but in other domains they prefer a lower $q$ (hence, some cumulativity).

Five levels of cognitive modelling:
1. General cognitive principles: e.g. optimize a target function.
2. Cognitive architecture: e.g. OT, HS, OT, 1HG, 2HG.
3. Cognitive infrastructure: e.g. value of $q$ in HG.
4. Knowledge: e.g. constraint ranking.
5. Implementation, which might be prone to error (performance).

Maturation vs. learning:
- Learning: acquiring knowledge based on observations possibly already in the pre-linguistic stage.
- Maturation: fine-tuning the infrastructure possibly due to physical and general cognitive development.

$\text{phonology}$ goes from HG to OT (from 1 + s to large): speed $\propto$ precision $\gg$ performance.

$\text{syntax-semantic}$ goes from HG to OT (from large to 1 + s): precision $\gg$ speed.

References


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