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RESTRICTIVENESS OF ERROR-DRIVEN RANKING ALGORITHMS

■ **EDRAs** — The target adult *phonotactics* is acquired early (Jusczyk *et. al.* 1993) and gradually (McLeod *et al.* 2001), i.e. through a sequence of intermediate, more restrictive grammars. The OT acquisition literature has endorsed *error-driven ranking algorithms* (EDRAs) as a plausible model of the child acquisition of phonotactics that offers a straightforward tool to model child acquisition paths. An EDRA maintains a current hypothesis of the target adult ranking. Following Boersma (1997, 1998, 2009), I represent this current hypothesis as a numerical *ranking vector*. Markedness constraints are initially ranked at the top and faithfulness constraints at the bottom, yielding a smallest language. Over time, the EDRA receives a stream of data from the target adult language. At each time, the EDRA checks whether its current ranking vector accounts for the current piece of data. If that is not the case, then the current ranking values of undominated loser-preferring constraints are decreased by a certain amount, say 1 for concreteness. And winner-preferring constraints are promoted by a certain *promotion amount* $p \geq 0$. The choice of this promotion amount p varies with different implementations: **(a)** Tesar and Smolensky's (1998) (gradual) EDCD sets $p = 0$, so that the algorithm performs no constraint promotion; **(b)** Boersma's (1997, 1998) GLA sets $p = 1$, so that the algorithm performs as much promotion as demotion; **(c)** Magri's (2012) *calibrated* EDRAs (CEDRAs) are in between, i.e. set $p < \frac{1}{w}$, where w is the number of winner-preferrers.

■ **Learning challenge** — Phonotactics is the knowledge of the distinction between licit and illicit forms. To learn the target adult phonotactics, an EDRA must therefore succeed on two fronts: it must learn to rule in every licit form (the *consistency* problem); and it must also learn to rule out every illicit form (the *restrictiveness* problem). A *convergent* EDRA makes only a finite number of updates before it settles on a final ranking vector consistent with the data. Convergent EDRAs, such as EDCD and CEDRAs, thus solve the first half of the problem of the acquisition of phonotactics, namely consistency. Yet, the final ranking vector could rule in too many forms (e.g., it could rule in any form, if all faithfulness constraints are ranked at the top), and thus fail at restrictiveness. Indeed, the OT computational literature has suggested that EDRAs are algorithmically too weak to guarantee restrictiveness and has thus endorsed the algorithmically stronger *batch* algorithms, that glimpse at the entire set of data at once, contrary to the cognitively more plausible EDRAs (Prince & Tesar 2004, Hayes 2004).

■ **Main result (informally)** — This talk provides the first positive result on restrictiveness of EDRAs, thus reconciling the *acquisition* perspective (that has endorsed EDRAs) and the *computational* perspective (that has doubted their computational soundness). Informally, the idea is that the relative ranking of the faithfulness constraints mainly governs the repair strategies. For the vast majority of cases, the relative ranking of the faithfulness constraints does not matter for phonotactics. In this talk, I show that EDRAs that do not promote too much (i.e., EDCD and CEDRAs, not the GLA) are always restrictive on this vast majority of languages that don't care about the relative ranking of the faithfulness constraints (called $\mathcal{F}$*-simple* languages).

■ **$\mathcal{F}$-simple languages** — A language is $\mathcal{F}$*-simple* provided the relative ranking of the faithfulness constraints does not matter, in the sense that there exists a *partial* ranking of the constraints that does not rank any two faithfulness constraints relative to each other and furthermore *generates* the language (in the sense that each of its *total refinements* generates the language in the usual OT sense; see also Yanovich 2011). To illustrate, consider the OT typology (1), based on Lombardi (1999) via Prince and Tesar (2004). The language (2a) is $\mathcal{F}$-simple, as it is generated by the partial ranking (2b) that does not rank F_1 relative to F_2. The language (3a) is not $\mathcal{F}$-simple, as it requires F_2 to be ranked above F_1 as in (3b).

(1) forms: $\{$ pa, ba, sa, za, apsa, apza, absa, abza $\}$

$$\text{constraints: } \left\{ \begin{array}{ll} F_1 = \text{IDENT[STOP-VOICING]} & M_1 = {}^*\text{[STOP-VOICING]} \\ F_2 = \text{IDENT[FRICATIVE-VOICING]} & M_2 = {}^*\text{[FRICATIVE-VOICING]} \\ \multicolumn{2}{c}{M_3 = \text{AGREE[VOICING]}} \end{array} \right\}$$

(2) a. $\{$ pa, ba, sa, za apsa, abza $\}$

b.
$$\begin{array}{ccccc} & & M_3 & & \\ & \diagup & & \diagdown & \\ F_1 & & & & F_2 \\ | & & & & | \\ M_1 & & & & M_2 \end{array}$$

(3) a. $\{$ pa, sa, za, apsa, abza $\}$

b.
$$\begin{array}{ccccc} M_3 & & \mathbf{F_2} & & \\ & \diagdown & | & \diagdown & \\ & & M_1 & & M_2 \\ & & | & & \\ & & \mathbf{F_1} & & \end{array}$$

$\mathcal{F}$-simple languages ar the vast majority, as the relative ranking of the faithfulness constraints mainly governs the repair strategies, not the language. In the talk, I will substantiate this claim with various examples of OT typology taken from the literature.

■ **Main result (formally)** — It is standard practice in the OT acquisition and computational literature to assume that the child takes the adult form (correctly perceived) as the corresponding underlying form. Thus, the sets of underlying and surface forms need to coincide, so that the same form can be construed as both an underlying and a surface form. It is then natural to assume that the *generating function* that in OT pairs an underlying form with its candidate surface forms is *symmetric*. In the sense that [abza] is a candidate for the underlying form /absa/ iff vice versa [absa] is a candidate for /abza/. The main result of this talk is (5): EDRAs that don't promote too much are restrictive on the vast majority of languages ($\mathcal{F}$-simple ones).

(5) If the generating function is symmetric:
a. EDCD (that performs no promotion) is restrictive on any $\mathcal{F}$-simple languages;
b. this result does *not* extend to the GLA (that performs too much promotion);
c. but it does extend to CEDRAs (that perform calibrated promotion).

■ **Remarks — (a)** On the one hand, EDRAs should not promote too much. In fact, the GLA (that promotes too much, i.e. demotes and promotes by the same amount) fails both at convergence (Pater 2008) and restrictiveness (5b). EDCD and CEDRAs (that promote less than they demote) are convergent (Tesar & Smolensky 1998; Magri 2012) and restrictive on $\mathcal{F}$-simple languages (5a,c). **(b)** On the other hand, EDRAs should perform some constraint promotion. In fact, although the focus of the talk is on restrictiveness on $\mathcal{F}$-simple languages, I will also discuss some cases of non $\mathcal{F}$-simple languages from the literature (such as (3a) above), showing that EDCD fails at restrictiveness while CEDRAs succeed on these test cases.

■ **Informal explanation of (5)** — A ranking that generates the target language enforces four types of ranking conditions: a faithfulness constraint needs to be ranked above another faithfulness constraint (6a); a markedness constraint needs to be ranked above a faithfulness constraint (6b); a markedness constraint needs to be ranked above another markedness constraint (6c); or a faithfulness constraint needs to be ranked above a markedness constraint (6d).

(6) a. $\begin{array}{c} F \\ | \\ F' \end{array}$ b. $\begin{array}{c} M \\ | \\ F \end{array}$ c. $\begin{array}{c} M \\ | \\ M' \end{array}$ d. $\begin{array}{c} F \\ | \\ M \end{array}$

If the target language is $\mathcal{F}$-simple, then the relative ranking of the faithfulness constraints does not matter. Thus, ranking conditions of type (6a) are not important. Furthermore, it turns out that EDRAs that don't promote too much always gets right ranking conditions of type (6b) when trained on an $\mathcal{F}$-simple language (this property does not extend to the GLA). We are thus left with the ranking conditions of type (6c) and (6d). One of these ranking conditions could be crucial for one of two reasons. One reason is that, if the EDRA fails to learn that ranking condition, then its final ranking will fail at *consistency*, namely it will fail to rule in some licit form. Another reason is that, if the EDRA fails to learn that ranking condition, then its final ranking will fail at *restrictivity*, namely it will fail to rule out some illicit form. It turns out that, if the generating function is symmetric and the target language is $\mathcal{F}$-simple, then the ranking conditions of type (6c) and (6d) are always crucial for consistency and can never be crucial for restrictiveness only. This means in turn that a convergent EDRA will always get these ranking conditions (6c) and (6d) right, as it is guaranteed to converge to a final ranking consistent with the target language. In the talk, I will provide a more explicit proof of (5).