MaxEnt fails at reasoning by transitivity

Arto Anttila (Stanford University) and Giorgio Magri (CNRS)

A RESULT ABOUT ME IMPLICATIONAL UNIVERSALS

We write $(\mathsf{x}, \mathsf{y}) \to (\widehat{\mathsf{x}}, \widehat{\mathsf{y}})$ to say that, for any grammar in a ME or NHG typology, realizing the underlying form $\widehat{\mathsf{x}}$ as the winner form $\widehat{\mathsf{y}}$ is at least as probable as realizing the underlying form x as the winner form y. This is a **probabilistic implicational universal** (Anttila and Magri 2017, 2025)

E.g. $(/\mathsf{cost{+}us}/, [\mathsf{cos.us}]) \to (/\mathsf{cost{+}me}/, [\mathsf{cos.me}])$ says that the ME or NHG typology satisfies the universal that t-deletion is always at least as probable before consonants as before vowels (Guy 1981)

If $(\mathsf{x}, \mathsf{y}) \to (\widehat{\mathsf{x}}, \widehat{\mathsf{y}})$ is a ME universal, for every consequent loser $\widehat{\mathsf{z}}$ and for every constraint $\widehat{C}_{\text{even}}$ that is even between the antecedent and consequent winners y and $\widehat{\mathsf{y}}$, there is some antecedent loser z that "is at least as good" in the sense that:

(A) the antecedent loser z violates that even constraint $\widehat{C}_{\text{even}}$ at most as much as the consequent loser $\widehat{\mathsf{z}}$

(B) the antecedent loser z satisfies every other even constraint C_{even} satisfied by the consequent loser $\widehat{\mathsf{z}}$

A PUZZLING EXAMPLE

Basic intuition:

- Nasal vowels are marked relative to oral vowels (Ferguson 1963, Greenberg 1966)
- This asymmetry is captured by *NASAL and IDENTNASAL
- Thus, we expect the universal antecedent → consequent to hold whenever the two mappings only differ because the antecedent has nasal vowels while the consequent has the corresponding oral vowels

When the basic intuition works:

- The mappings $(/\tilde{\text{æ}}\text{d+z}/, [\tilde{\text{æ}}\text{ds}])$ and $(/\text{æb+z}/, [\text{æbs}])$ differ for nasality but pattern alike for voicing
- We add three constraints for voicing: NOVOICE, IDENTROOT and IDENTSUFFIX
- Candidates are obtained by changing vowel nasality and obstruent voicing
- NHG and ME validate the universal $(/\tilde{\text{æ}}\text{d+z}/, [\tilde{\text{æ}}\text{ds}]) \to (/\text{æb+z}/, [\text{æbs}])$ and thus both comply with our intuition

When the basic intuition fails:

- Let us add SSP-PLACE that prohibits rising sonority in codas (voiceless+voiced) only if the segments share place (cf. Rose and Walker 2004: 491, Coetzee and Pater 2008), a kind of partial geminate behavior
- With SSP-PLACE, the universal $(/\tilde{\text{æ}}\text{d+z}/, [\tilde{\text{æ}}\text{ds}]) \to (/\text{æb+z}/, [\text{æbs}])$ only holds in NHG but fails in ME!
- ME flouts our basic intuition. Why?

EXPLAINING THE EXAMPLE

Reasoning by transitivity:

/æ̃d+z/ ☞ [æ̃ds]	IDROOT	NOVCE	IDSFX	SSP-PLACE
[æ̃ts]	W	L		
[æ̃dz]		W	L	
[æ̃tz]	W		L	W

/æb+z/ ☞ [æbs]	IDROOTT	NOVCE	IDSFX	SSP-PLACE
[æpz]	W		L	

- In order for the winner [æ̃ds] to beat the loser [æ̃ts] in OT, IDENTROOT must outrank NOVOICE
- In order for the winner [æ̃ds] to also beat the loser [æ̃dz], NOVOICE must in turn outrank IDENTSUFFIX
- By transitivity, IDENTROOT ≫ IDENTSUFFIX, ensuring that the winner [æbs] beats the loser [æpz]
- Without SSP-PLACE, this ranking IDROOT ≫ IDSUFFIX does not need to be inferred by transitivity: it is required in order for the winner [æ̃ds] to beat the loser [æ̃tz].
- With SSP-PLACE, this ranking IDROOT ≫ IDSUFFIX can only be inferred by transitivity
- Thus with SSP-PLACE, the universal $(/\tilde{\text{æ}}\text{d+z}/, [\tilde{\text{æ}}\text{ds}]) \to (/\text{æb+z}/, [\text{æbs}])$ holds *by transitivity*.

Reasoning by transitivity fails in ME:

	IDROOT	NOVCE	IDSFX	SSP-PLACE
/æ̃d+z/ ☞ [æ̃ds]		1	1	
[æ̃ts]	1		1	
[æ̃dz]		2		
[æ̃tz]	1	1		1

/æb+z/ ☞ [æbs]		1	1	
[æpz]	1	1		

- Constraints all even between winners [æ̃ds] and [æbs]
- Does some antecedent loser do as well as the consequent loser [æpz] in the sense of conditions (**A**) and (**B**)?
- The losers [æ̃ts] and [æ̃tz] flout (**B**): they violate IDSUFFIX and SSP-PLACE while the loser [æpz] satisfies both
- The loser [æ̃dz] satisfies both IDSUFFIX and SSP-PLACE as required by (B), but flouts (A): it violates NOVOICE more (twice) than [æpz] (only once).
- With SSP-PLACE, the boxed result thus predicts that the universal $(/\tilde{\text{æ}}\text{d+z}/, [\tilde{\text{æ}}\text{ds}]) \to (/\text{æb+z}/, [\text{æbs}])$ fails in ME
- Without SSP-PLACE, the losers [æpz] and [æ̃tz] share the same violations, thus satisfying both (**A**) and (**B**).

CONCLUSION

OT, HG, NHG support reasoning by transitivity: if C_1 dominates C_2, and C_2 dominates C_3, C_1 dominates C_3

Based on a general result about ME universals, we have shown that ME does not support reasoning by transitivity