Tree Adjunction as Minimalist Lowering

Thomas Graf
tgraf@ucla.edu
tgraf.bol.ucla.edu

University of California, Los Angeles

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MGs vs TAG

- **String Languages**

$$\text{CFG} \subset \text{LIG} \equiv \textbf{TAG} \equiv \text{CCG} \subset \text{LCFRS} \equiv \text{MCTAG} \equiv \textbf{MG}$$

- **Tree Languages**

$$\text{TAG} \not\subseteq \text{MG} \ \& \ \text{MG} \not\subseteq \text{TAG}$$

Question

Can MGs be extended to subsume TAG on a tree level?

Outline

Movement-Generalized MGs

- **Standard MGs** (Stabler 1997, 2011)
  - Inspired by Chomsky's Minimalist Program
  - Two structure building operations:
    Merge (combines trees) and Move (displaces subtrees)
  - Both operations are controlled by features on the lexical items.
- **Movement-Generalized MGs** (Graf 2012)
  - Extend MGs with a template for defining new variants of Move **without increasing weak generative capacity**
  - Parameters: size of displaced constituent, linear order, direction of Move (upwards/downwards)
  - Defined in terms of their (regular) derivation tree language plus a transduction to derived trees.

Defining MGs via Their Derivations: Slices

We start with a derivation-tree based definition of MGs without movement.

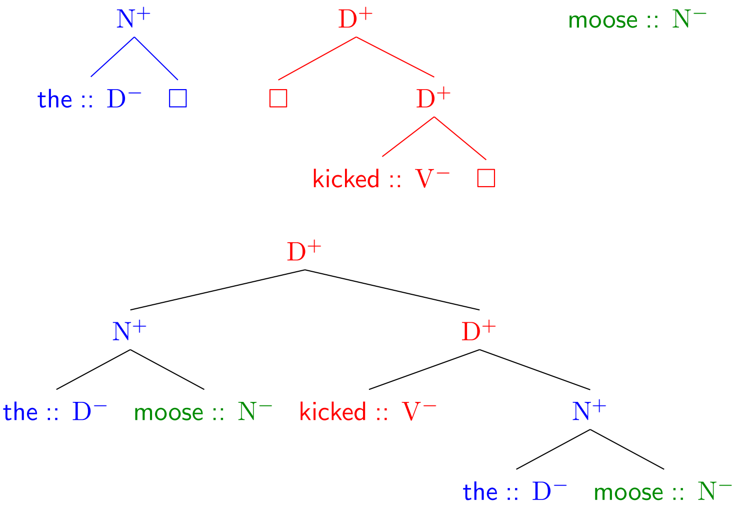
Slices (≈ elementary trees/phrase projected by a lexical item)

A **slice** is a strictly binary branching tree such that

- every interior node is labeled with a positive polarity Merge feature,
- every interior node is a mother of exactly one node labeled $\Box$,
- exactly one leaf node is a lexical item (the **head**) with a negative polarity Merge feature.

A Minimalist derivation is a combination of slices satisfying certain conditions.

Example: Slices and a Combination Thereof



Conditions on Merge

Constraint 1: Merge

Every interior node with a positive polarity Merge feature F^{+} immediately dominates the root of a slice whose head has the matching feature F^{-}.

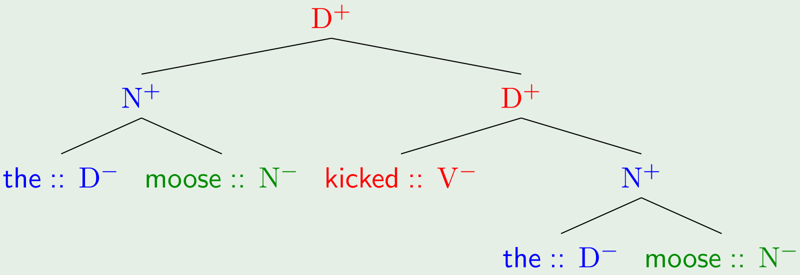
Constraint 2: Final

The head of the root of the derivation must have a distinguished **final** Merge feature.

Mapping to Derived Trees

Replace interior node labels by arrows pointing in the direction of the head of the slice.

Example



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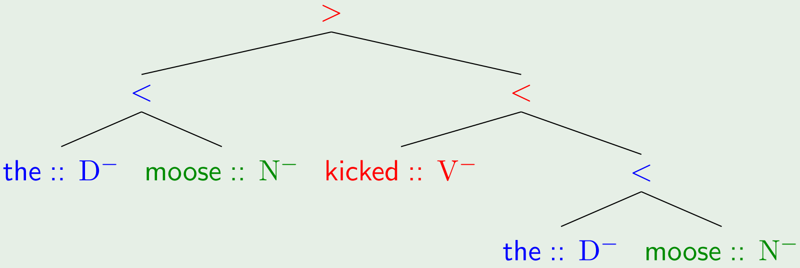
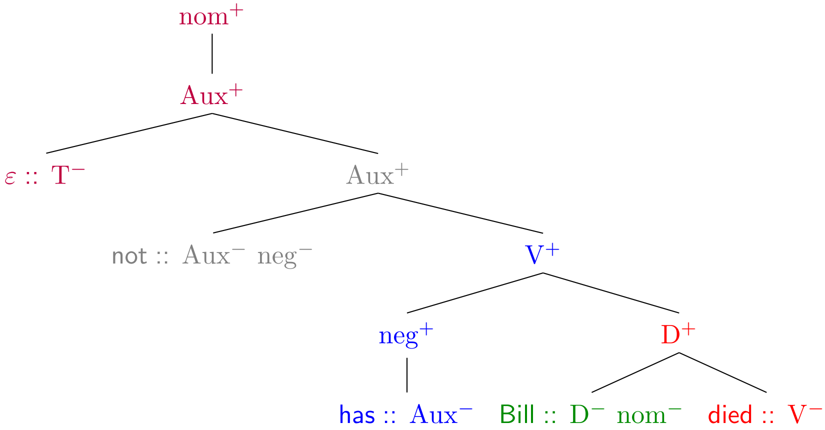


Move

In derivation trees, Move is only indicated by unary branching — **no actual displacement occurs** before the mapping to derived trees.



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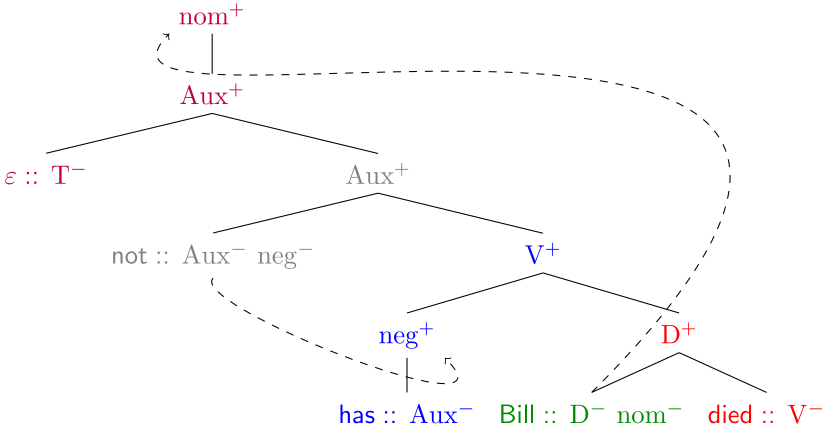
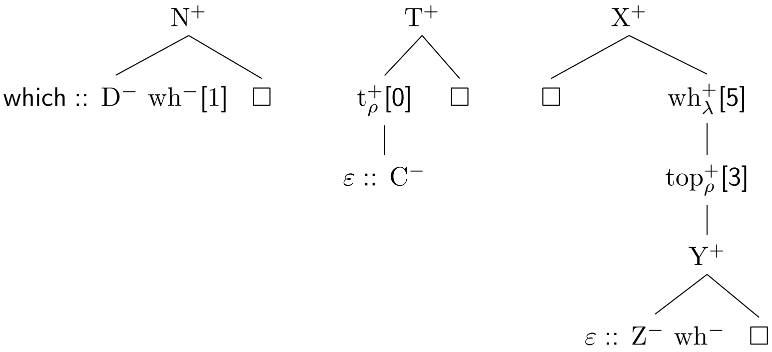


Slices Again

Slices Addendum

- A slice may contain unary branching nodes.
- All unary branching nodes — and only those — are labeled with a positive polarity Move feature with directionality $d \in \{\lambda, \rho\}$.
- A head's negative polarity Merge feature may be followed by a finite number of negative Move features.
- Every Move feature furthermore has a non-negative size value indicating the root of the subtree to be displaced.

Example: Slices involving Move



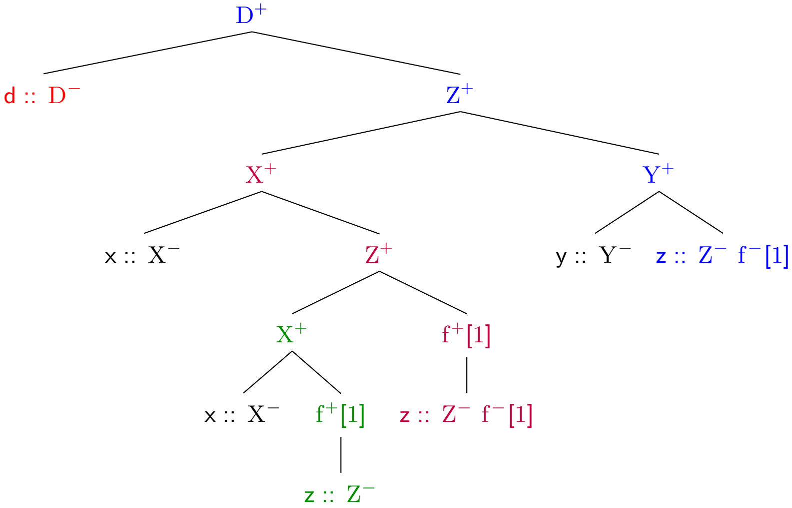
What are the Relevant Move Nodes?

Finding Occurrences for Reset Lowering

Move node m with feature $f^{+}[i]$, $i \geq 0$, is an **occurrence** of head h iff

- h has a matching feature $f^{-}[i]$, and
- the i-th node n of the slice of h c-commands m in the derivation tree, and
- there is no head h' satisfying the previous conditions that is c-commanded by n.

Find the Occurrences!



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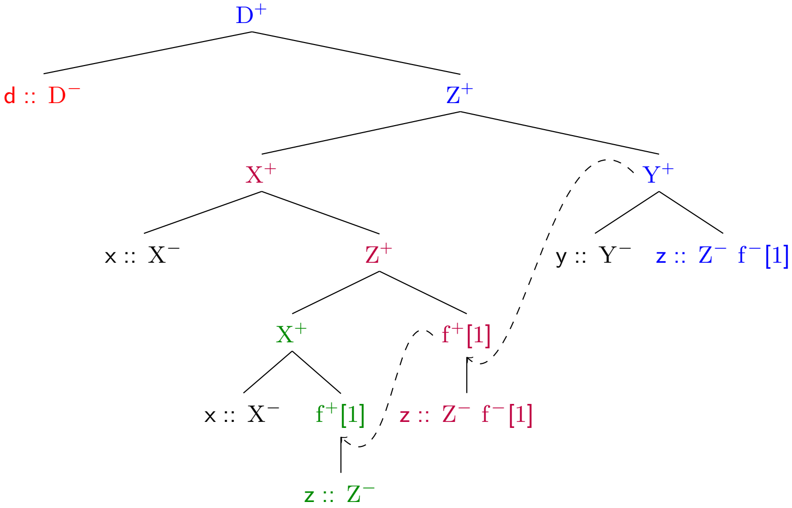

Constraints on Move

Constraint 1: Move

For every head h with n negative Move features, $n \geq 1$, there exist n distinct Move nodes that are occurrences of h.

Constraint 2: SMC

Every Move node is an occurrence of exactly one head.

Corollary for Reset Lowering

- No head has two negative Move features with both identical feature names and identical size values.
- The order of a head's negative Move features is irrelevant.

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General Strategy

- **Given**: derivation tree language of some TAG G
- Step 1: Put G into a particular normal form.
- Step 2: Define a mapping from TAG derivations to Minimalist derivations.
    - Adjunction is Merger of auxiliary tree T at adjunction site A followed by lowering of the material below A to T's foot node.
- Step 3: Ensure the output is an MDTL.

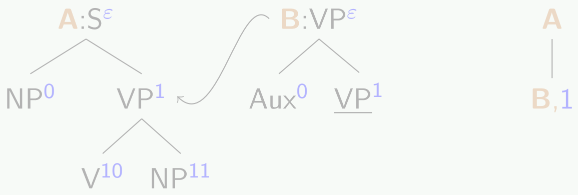
TAG Derivations

Definition (TAG Derivation Tree)

A **TAG derivation tree** is a finite tree with each node's label consisting of

- the **name** of an elementary tree e, and
- the **address** of the node where e is adjoined/substituted (if such a node exists).

Example



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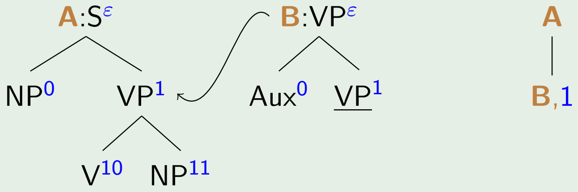


Preprocessing

All elementary trees must be

- strictly binary branching, and
- projective.

Definition (Projectivity)

Every interior node is a projection of some (possibly empty) leaf that is neither a foot node nor a substitution node.

Initial Trees

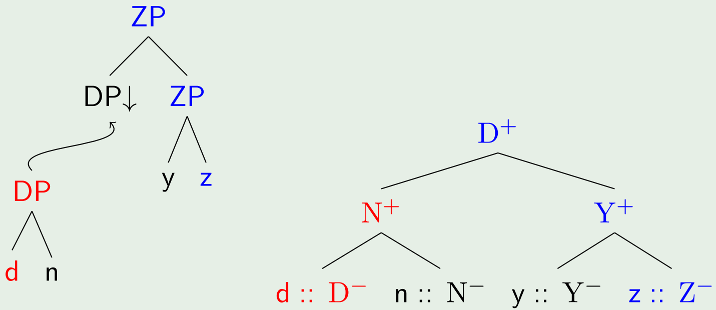
Trees containing neither foot nodes nor substitution nodes are straight-forward, thanks to projectivity:

Example

Substitution

Substitution is handled by Merge, too:

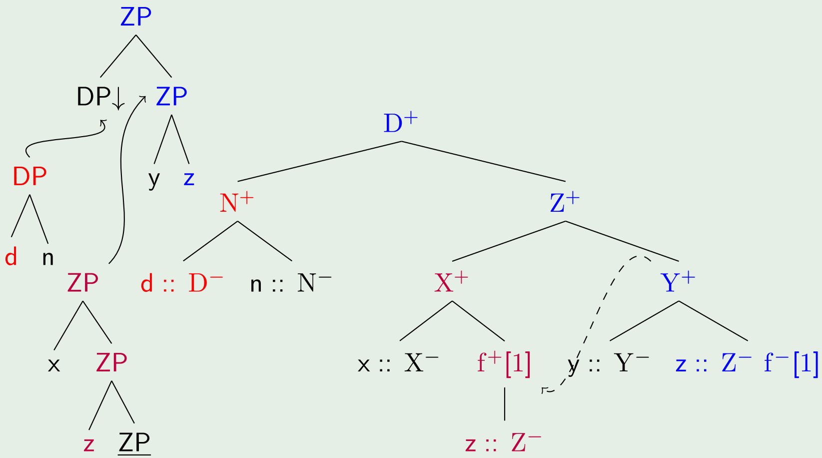
Example



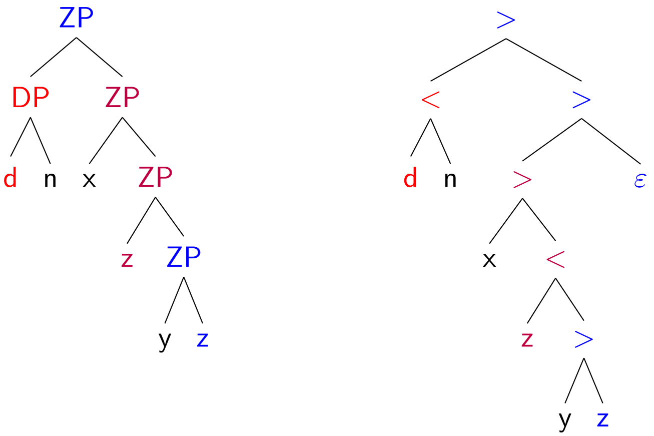
Tree Adjunction

Tree Adjunction ≡ Merge + Reset Lowering

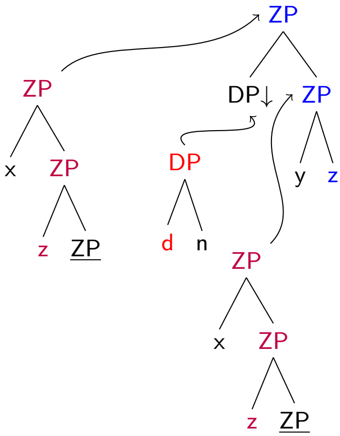
Example



Comparing the Derived Trees



An Example with Multiple Adjunctions



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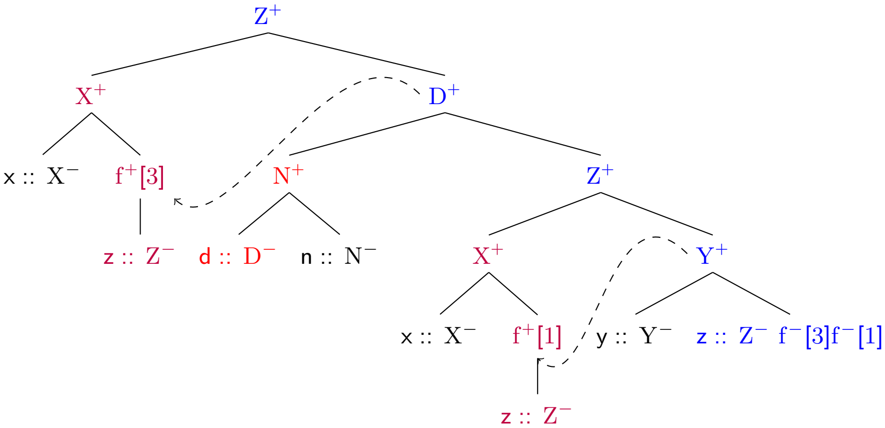

Observation

An elementary tree may have multiple MG correspondents.

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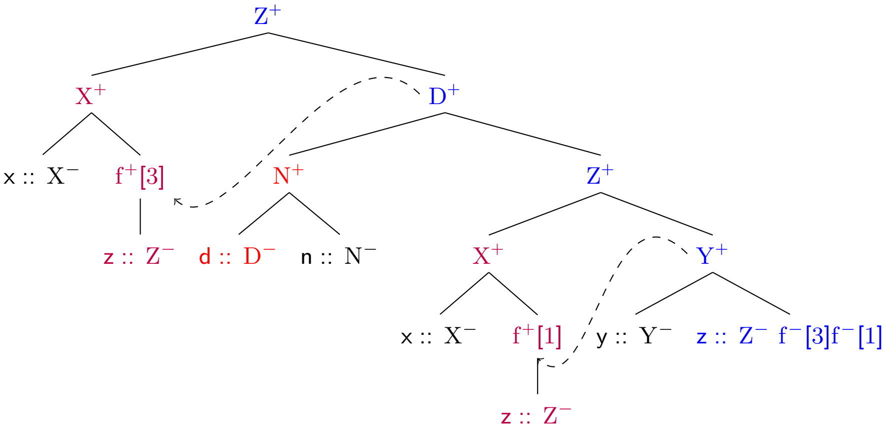

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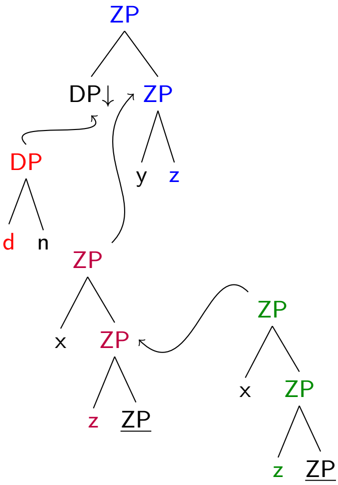

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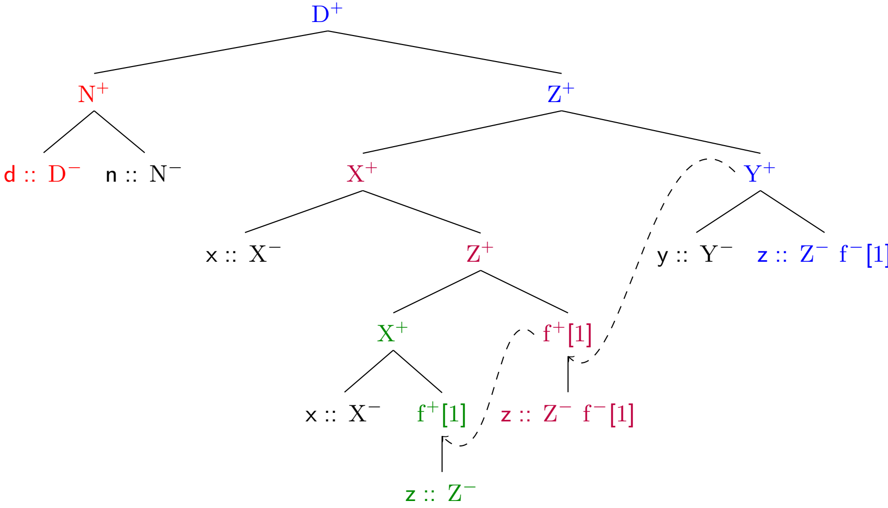

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A single feature name suffices for all instances of reset lowering.

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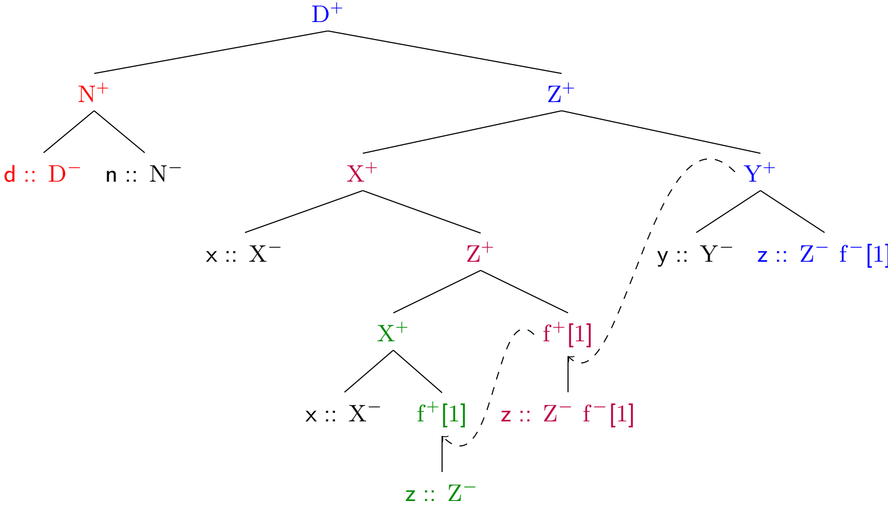

Observation

A single feature name suffices for all instances of reset lowering.

But is it a Minimalist Derivation Tree Language?

- The output L of the translation might not be a well-formed MDTL (some combinations of slices might be missing).
- However:
  - TAG derivation tree languages are regular,
  - the translation is a linear tree transduction,
  - regular tree languages are closed under linear tree transduction,
  - MDTLs are (almost) closed under intersection with regular tree languages (Graf 2011; Kobele 2011).
- Take the smallest superset L' of L that is an MDTL (L' is guaranteed to exist) and intersect it with L.
- This yields the MDTL of some MG that generates all derived trees of the original TAG, and only those.

Expressivity of MGs with Reset Lowering

- Even with only one feature name for reset lowering it is still possible to generate

$$a_1^n \ a_2^n \cdots a_{k-1}^n \ a_k^n$$

  for any $k \geq 1$.
- This is so because features are considered identical by the SMC only if they have **the same size value**.
  $\Rightarrow$ size value can emulate additional feature names
- If the SMC ignores the size value, only TALs can be generated.

Conclusion

- **Issue**
  - MGs have greater weak generative capacity than TAG.
  - Still the two generate incomparable classes of tree languages.
  - Can this gap be bridged?
- **Solution**
  - Adjunction cuts a tree t into two halves t_1 and t_2, inserts new material and puts it all back together.
  - MGs generate the auxiliary tree in the intended position and lower t_2 to the foot node.
- **Future Research**
  - does not generalize well to higher-order TAG (Rogers 2003) — MGs with multiple feature names resemble MCTAG
  - Reset Lowering is not a particularly natural movement type.
  - Sideward Movement should also work, though.
  - More generally: What property must a movement type satisfy in order to subsume (higher-order) Tree Adjunction?

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