# A Tier-Based Model of Syntactic Agreement

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# Some (paradoxical) properties of agreement

| Usually... | but... |
|---|---|
| Applies over a distance | Subject to blockers |
| Blockers are predictable | Vary across dependencies/languages |
| Targets the closest visible DP | Which DPs are visible varies |
| Probe c-commands goal | Sometimes reversed |
| One probe $\leftrightarrow$ one goal | Sometimes many-to-one |

# Overview

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- Provides a unified model of locality restrictions
- Shows parallels within/across domains
- Derives typology from issues of efficient computation

# Roadmap

1. What is a TSL pattern?
2. A TSL model of agreement
3. Consequences for locality
4. Typological variation
5. Parallels with phonology
6. Strengths and limitations of the model

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# More about TSL

- Originally defined to model phonological patterns (Heinz et al. 2011)
- Argued to be relevant in syntax as well (Graf 2022a)
- Inspired by but distinct from autosegmental phonology (Goldsmith 1976)
- Special relational structure (tier successor) with very weak constraint logic (banned substrings) (Lambert et al. 2021)
- By hypothesis, we only need a window of size two (McMullin 2016)

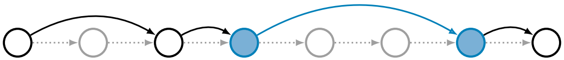

Figure 1: TSL string model with constraint window of size two

See Appendix 1 for another example and a formal definition.

# A TSL Model of Agreement

# Setup

**Assumptions:**

- Bare phrase structure, feature-driven selection, movement, ...
- Agreement between elements with initially unvalued features (probes) and elements which provide those values (goals)

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**Assumptions:**

- Bare phrase structure, feature-driven selection, movement, ...
- Agreement between elements with initially unvalued features (probes) and elements which provide those values (goals)

**Question:** What are the possible arrangements of probes and goals for agreement?

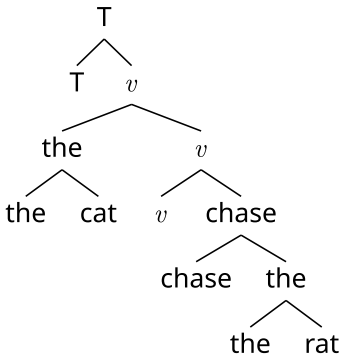
**Answer:** They are TSL constraints on the search path of the probe.

# The search path

The search path follows the **derivational command (d-command)** relation (Graf and Shafiei 2019).

- Head < Spec < Comp
- d-command order $\approx$ height of XP
  $\approx$ order of last merge
  $\approx$ reverse order of selection
- Projections of a head are not distinguished.
- At each branching point, follow the complement spine (Graf and De Santo 2019).

ex. ‘The cat chases the rats.’

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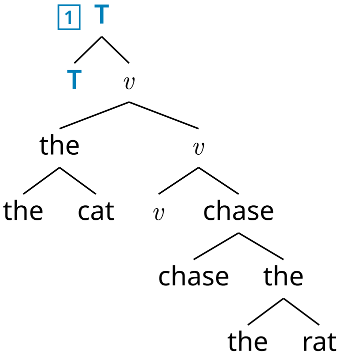


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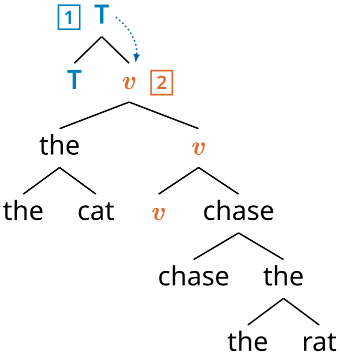


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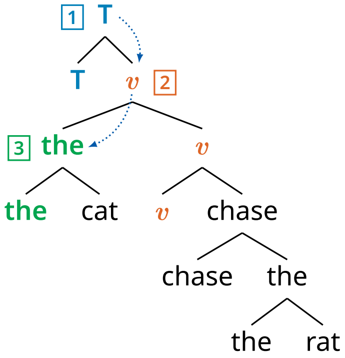


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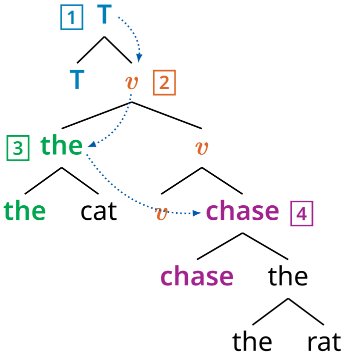


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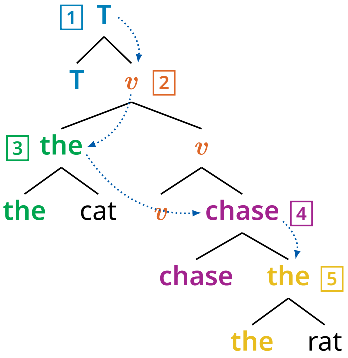


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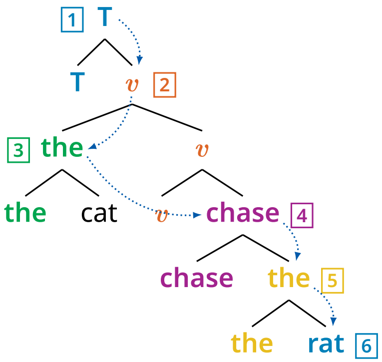


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**Notation:** $p\phi$ = probe $g\phi$ = actual goal $\phi$ = other potential goal

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**General principle:** a probe must be immediately followed by its goal on a tier projected from the search path (and vice versa).

**Notation:** $p\phi$ = probe    $g\phi$ = actual goal    $\phi$ = other potential goal

**Example: (canonical) subject-verb agreement**

| | |
|---|---|
| Tier elements: | All agreeing elements (T/D) and blockers (C) |
| Constraints: | $*\mathrm{T}_{[p\phi]} \cdot \mathrm{D}_{[\phi]}$, $*\mathrm{T}_{[p\phi]} \cdot \mathrm{C}$, $*\mathrm{D} \cdot \mathrm{D}_{[g\phi]}$, $*\mathrm{D}_{[g\phi]} \cdot \mathrm{D}_{[g\phi]}$, $\ldots$ |

# The TSL analysis – example

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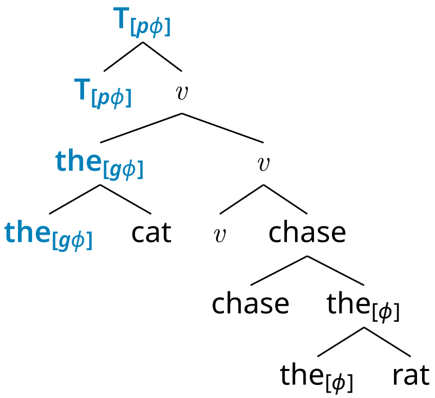
ex. The cat **chases** the rats.

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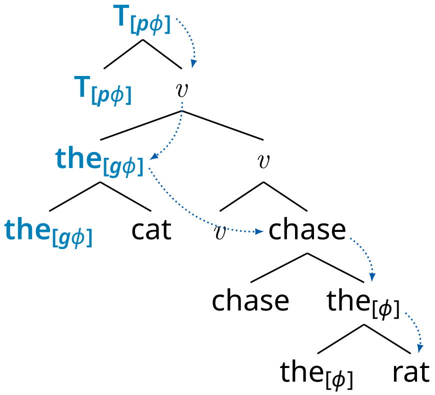


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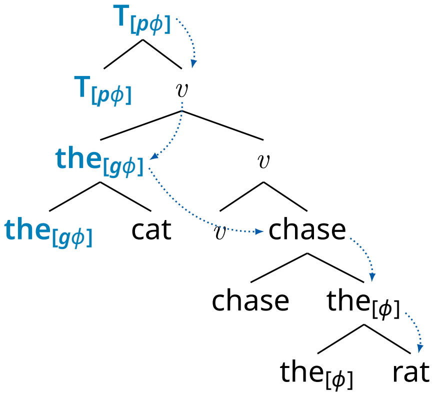


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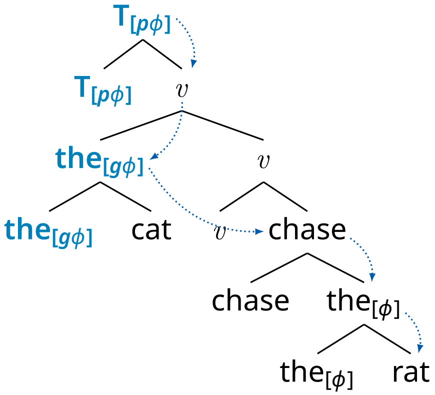


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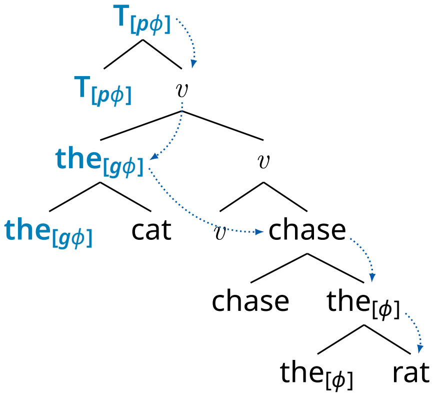


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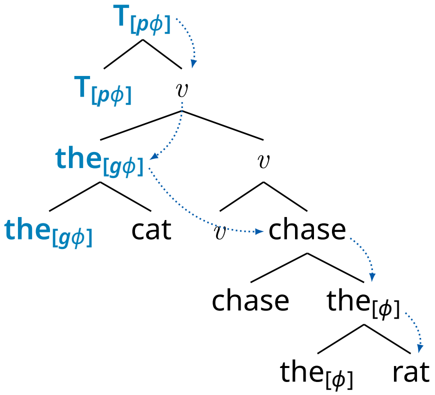
Violations: n/a

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# Consequences for locality

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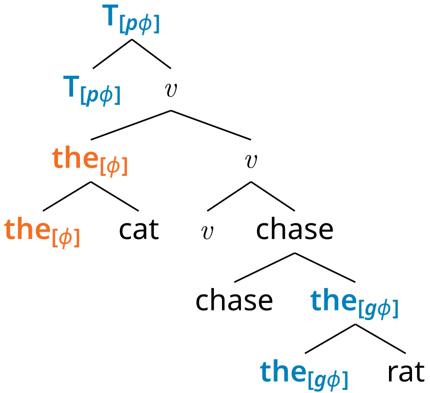
- **Minimality:** if another potential goal intervenes on the tier, agreement is blocked.
- **Invisibility:** if a DP is omitted from the tier, long-distance agreement is possible.
  - e.g. agreement across *there*, case-sensitive agreement
- **Blocking:** if a non-agreeing element intervenes on the tier, agreement is blocked.
  - e.g. probe horizons (Keine 2019), defective intervention

# Minimality

If another potential goal intervenes on the tier, agreement is blocked.

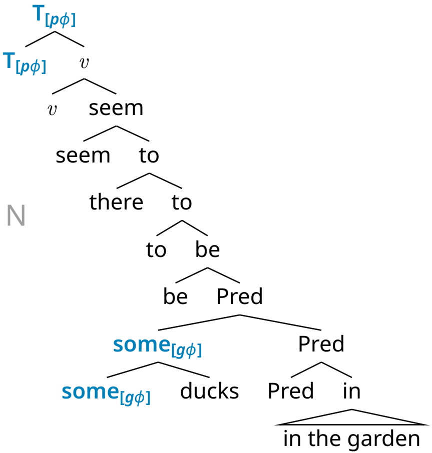
ex. * The cat **chase** <u>the rats</u>.

| | |
|---|---|
| Path: | $\mathbf{T_{[p\phi]}} \cdot v \cdot \mathbf{D_{[\phi]}} \cdot \mathrm{V} \cdot \mathbf{D_{[g\phi]}} \cdot \mathrm{N}$ |
| Tier: | $\mathbf{T_{[p\phi]}} \cdot \mathbf{D_{[\phi]}} \cdot \mathbf{D_{[g\phi]}}$ |
| Violations: | $*\mathrm{T_{[p\phi]}} \cdot \mathrm{D_{[\phi]}}$, $*\mathrm{D_{[\phi]}} \cdot \mathrm{D_{[g\phi]}}$ |



# Invisibility

If a DP is omitted from the tier, long-distance agreement is possible.




ex. There **seem** to be <u>some ducks</u> in the garden.

| | |
|---|---|
| Path: | $\mathbf{T}_{[p\phi]} \cdot v \cdot \mathrm{V} \cdot \mathrm{T} \cdot \mathrm{there} \cdot v \cdot \mathbf{D}_{[g\phi]} \cdot \mathrm{P} \cdot \mathrm{D}_{[\phi]} \cdot \mathrm{N}$ |
| Tier: | $\mathbf{T}_{[p\phi]} \cdot \mathbf{D}_{[g\phi]} \cdot \mathrm{D}_{[\phi]}$ |
| Violations: | n/a |

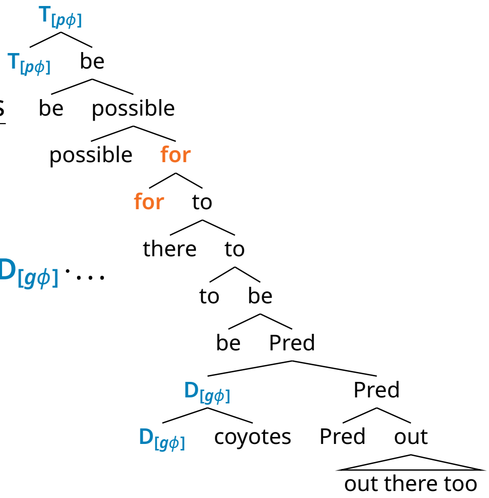
We can handle optional default agreement in several ways. Ask me if you are interested.

# Blocking

If a non-agreeing element is projected on the tier, agreement is blocked.

ex. * It **are** possible for there to be coyotes out there too.

cf. It **is** possible…




Path: $\mathbf{T}_{[p\phi]} \cdot v \cdot \mathrm{V} \cdot \mathbf{C} \cdot \mathrm{T} \cdot \text{there} \cdot v \cdot \text{Pred} \cdot \mathbf{D}_{[g\phi]} \cdot \ldots$

Tier: $\mathbf{T}_{[p\phi]} \cdot \mathbf{C} \cdot \mathbf{D}_{[g\phi]}$

Violations: $*\mathrm{T}_{[p\phi]} \cdot \mathrm{C}$, $*\mathrm{C} \cdot \mathrm{D}_{[g\phi]}$

Assume for the sake of demonstration that expletive "it" is inserted late and does not agree.

# Locality – summary

Locality phenomena derive from TSL with a window of size two, a.k.a. **TSL-2**.

- Minimality: closer potential goal intervenes

$$\mathrm{T}_{[p\phi]} \ldots \mathbf{D}_{[\phi]} \ldots \mathrm{D}_{[g\phi]}$$

- Invisibility: hypothetical goal does not appear on tier

$$\mathrm{T}_{[p\phi]} \ldots \text{there} \ldots \mathrm{D}_{[g\phi]}$$

- Blocking: some non-agreeing element intervenes on the tier

$$\mathrm{T}_{[p\phi]} \ldots \mathbf{C} \ldots \mathrm{D}_{[g\phi]}$$

# Importance of the finite window

- Neither tiers nor the finite window alone are adequate.
  - Tiers allow long-distance dependencies to be treated as if local.
  - The finite constraint window limits the power of the system.
  - Together, they create the right type of relativized locality.

See Appendix 3 and Appendix 4 for details.

# Typological variation

# Parameters for variation

The parameters for TSL-2 (tier elements and constraints) correspond neatly to variation in long-distance dependencies.

- Visibility — which elements are relevant and which are ignored?
  - Case-sensitive agreement (cf. Bobaljik 2008; Preminger 2014)
- Iteration — if you allow AB and BB, then you get ABB, ABBB, etc.
  - Case/gender/number concord
- Directionality — do we ban AB or BA?
  - Upward/downward agreement (cf. Chomsky 2000; Zeijlstra 2012)

# Case-sensitive agreement

In Hindi, the verb agrees with the closest *nominative* argument, which may not be the subject.

(1) Hindi verbal agreement ignores ergatives (Mahajan 1990)

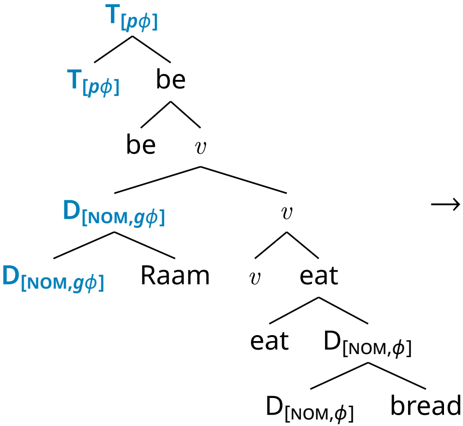
a. Raam roTii khaataa thaa.
Raam.M.**NOM** bread.F.NOM eat.IPFV.M be.PST.M
'Raam ate bread (habitually).'

b. Raam-ne roTii khaayii.
Raam.M-**ERG** bread.F.NOM eat.PFV.F
'Raam ate bread.'

**Analysis:** Project D only if nominative. Tier constraints are unchanged.

# Case-sensitive agreement (2)

‘Raam ate bread (habitually).’ (Nominative subject, subject agrees)




$$\rightarrow \quad \mathrm{T}_{[p\phi]} \cdot \mathrm{be} \cdot v \cdot \mathrm{D}_{[\mathrm{NOM},g\phi]} \cdot \mathrm{eat} \cdot \mathrm{D}_{[\mathrm{NOM},\phi]} \cdot \mathrm{bread}$$

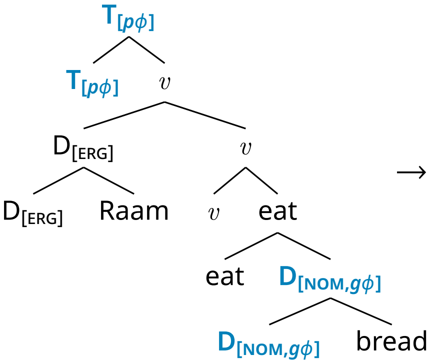
$$\downarrow$$

$$\mathrm{T}_{[p\phi]} \cdot \mathrm{D}_{[\mathrm{NOM},g\phi]} \cdot \mathrm{D}_{[\mathrm{NOM},\phi]}$$

We ignore agreement on the non-finite verb for simplicity. Concord will be discussed later.

# Case-sensitive agreement (3)

‘Raam ate bread.’ (Ergative subject, object agrees)




$$\rightarrow \mathbf{T}_{[p\phi]} \cdot v \cdot \mathrm{D}_{[\mathrm{ERG}]} \cdot \text{eat} \cdot \mathbf{D}_{[\mathrm{NOM},g\phi]} \cdot \text{bread}$$

$$\downarrow$$

$$\mathbf{T}_{[p\phi]} \cdot \mathbf{D}_{[\mathrm{NOM},g\phi]}$$

# Ergative ≠ Invisible

Ergatives are not invisible in Nepali (though datives are).

(2) Agreement with ergative in Nepali (Coon and Parker 2019)

a. Maile yas pasal-mā patrikaā kin-ē.
**1SG.ERG** DEM store-LOC newspaper.ABS buy-**1SG**
'I bought the newspaper in this store.'

b. Ma thag-ī-ē.
**1SG.ABS** cheat-PASS-**1SG**
'I was cheated.'

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   ‘I was cheated.’

No problem! We project $D_{[NOM]}$ and $D_{[ERG]}$ but not $D_{[DAT]}$.

# Formal vs substantive constraints

- Bobaljik's (2008) case visibility hierarchy: Nom > Acc/Erg > Obliques
- We can encode the attested patterns in a TSL-2 grammar, but the implicational hierarchy itself requires a separate explanation.

# Concord in the DP

To allow for iterated agreement, just permit $p\phi \cdot p\phi$.

(4) Gender concord in German

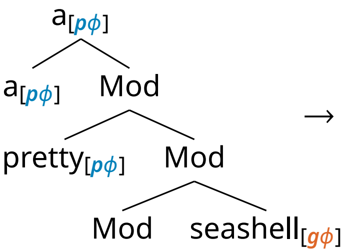
Ich habe [eine hübsche Muschel] gefunden.
I have [a.**F** pretty.**F** seashell.**F**] found

'I found a pretty seashell.'

**Analysis:** Ignore Mod on the tier, permit $\mathrm{D}_{[p\phi]} \cdot \mathrm{A}_{[p\phi]}$ and $\mathrm{A}_{[p\phi]} \cdot \mathrm{A}_{[p\phi]}$.

# Concord in the DP (2)

**Analysis:** Ignore Mod on the tier, permit $\mathrm{D}_{[p\phi]} \cdot \mathrm{A}_{[p\phi]}$ and $\mathrm{A}_{[p\phi]} \cdot \mathrm{A}_{[p\phi]}$.




$$\rightarrow \quad \mathrm{D}_{[p\phi]} \cdot \mathrm{Mod} \cdot \mathrm{A}_{[p\phi]} \cdot \mathrm{N}_{[g\phi]}$$

$$\downarrow$$

$$\mathrm{D}_{[p\phi]} \cdot \mathrm{A}_{[p\phi]} \cdot \mathrm{N}_{[g\phi]}$$

The Mod head is not crucial. If direct adjunction is used, then the pattern is local: the tier contains everything.

# Upward agreement

If the constraints are mirrored, then the direction of agreement is reversed.

(5) Case concord in German

| | | | | | |
|---|---|---|---|---|---|
| Ich | habe | [eine | hübsche | Muschel] | gefunden. |
| I | have | [a.ACC | pretty.ACC | seashell.ACC] | found |

**Analysis:** allow $\mathrm{D}_{[g\mathrm{Case}]} \cdot \mathrm{A}_{[p\mathrm{Case}]}$ instead of $\mathrm{D}_{[p\mathrm{Case}]} \cdot \mathrm{A}_{[g\mathrm{Case}]}$, etc.

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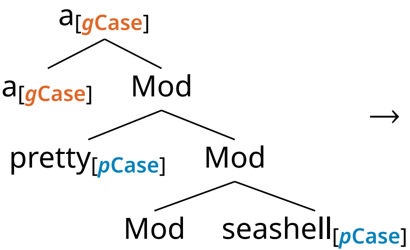


$$\longrightarrow \quad \mathrm{D}_{[g\mathrm{Case}]} \cdot \mathrm{Mod} \cdot \mathrm{A}_{[p\mathrm{Case}]} \cdot \mathrm{N}_{[p\mathrm{Case}]}$$

$$\downarrow$$

$$\mathrm{D}_{[g\mathrm{Case}]} \cdot \mathrm{A}_{[p\mathrm{Case}]} \cdot \mathrm{N}_{[p\mathrm{Case}]}$$

We can handle definiteness agreement on the adjective (ignored here) in the same way.

# What does it mean to probe upward?

- In the MG derivation tree formalism (Graf and Shafiei 2019), we have a static representation of the entire derivation, so there is no problem.
- In a bottom-up Minimalist derivation, it is not obvious what it means for a probe to search upward. Some possibilities:
  - Let valued features search downward for unvalued features (Adger 2003)
  - Replace the search metaphor with the sliding window metaphor

# Typological variation – summary

| Example | Tier Elements | Tier Constraints |
|---|---|---|

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| Concord within DP | All D/Adj/N | Allow sequential $p\phi$ |

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| --- | --- | --- |
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| Case-sensitive agreement | All T/C<br>D only if right case | (as above) |
| Concord within DP | All D/Adj/N | Allow sequential $p\phi$ |
| Upward agreement | (as above) | Swap order of $p\phi/g\phi$ |

# Parallels with phonology

| Parameter |
| --- |
| Participants |
| Invisible |
| Blockers |
| Directionality |
| Chaining |

See McMullin (2016) and McMullin and Hansson (2016) regarding long-distance harmony.

# Parallels with phonology

| Parameter | $\phi$-agreement |
|---|---|
| Participants | Probe and most DPs |
| Invisible | Non-DPs, some DPs |
| Blockers | Finite C, some DPs |
| Directionality | Downward/upward |
| Chaining | Concord/no concord |

See McMullin (2016) and McMullin and Hansson (2016) regarding long-distance harmony.

# Parallels with phonology

| Parameter | $\phi$-agreement | Vowel harmony |
|---|---|---|
| Participants | Probe and most DPs | Most vowels |
| Invisible | Non-DPs, some DPs | Consonants, some vowels |
| Blockers | Finite C, some DPs | Some vowels |
| Directionality | Downward/upward | Progressive/regressive |
| Chaining | Concord/no concord | Spreading/“icy targets” |

See McMullin (2016) and McMullin and Hansson (2016) regarding long-distance harmony.

# What else is TSL?

| Phenomenon | One line summary |
|---|---|
| Defective intervention* | Some DPs project even if they are never $g\phi$ |
| Probe horizons (Keine 2019) | V/$v$/T/C project even if they are never $p\phi$ |
| A′-agreement (Van Urk 2015)* | Only project DPs with a certain A′ feature |
| Omnivorous number | Only project DPs with [PL], not [SG] |
| Upward C agr. (Diercks 2013)* | C probes up, only project DPs that EPP-move |
| Default agreement* | Allow lone $p\phi$ under limited circumstances |
| Interaction/Satisfaction (Deal 2015)* | Allow multiple $g\phi$ under limited circumstances |
| Independent subfeatures of $\phi$ | Each probe gets its own tier/constraints |

Also: many movement (Graf 2022b) and case patterns (Vu et al. 2019; Hanson 2023b), though these analyses use a different tier-based model.

*See Hanson (2023a) and Hanson (2024a) for details.

# What *isn't* TSL?

Not all linguistic patterns are TSL. Of those that are not, most appear to be SS-TSL (structure-sensitive TSL). These include:

- Some long-distance harmony (De Santo and Graf 2019; Graf and Mayer 2018)
- Some tone patterns (e.g. unbounded tone plateauing)
- Some binding rules (Graf and Shafiei 2019)

# Strengths and limitations of the model

# Advantages of the model

- Clear separation of concerns:
  - Structural representation
  - Computations over said structure
  - Substance of elements of structure

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- Clear separation of concerns:
  - Structural representation
  - Computations over said structure
  - Substance of elements of structure
- Insights:
  - Agreement is especially similar to harmony as both involve feature matching; the same seems to be true of movement
  - If case is different, this is plausibly because it involves different kinds of constraints (e.g. dependent case)

# Limitations of the model

Puzzles for the path-based approach:

- What to do about violations of c-command (e.g. sub-command)?
- How to handle exceptions to the complement spine generalization?

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- What to do about violations of c-command (e.g. sub-command)?
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What the TSL model (alone) does not tell us:

- Why does case matter for $\phi$-agreement? Why should nominatives always be visible, ergatives sometimes visible, and datives usually invisible?
- Why do probes seem to look downward more often than upward?
- How do children identify the visible elements and constraints for each dependency? (see Hanson 2024b; Belth 2023)

# Summary

- Agreement patterns in syntax are largely TSL with a window size of 2.

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# Summary

- Agreement patterns in syntax are largely TSL with a window size of 2.
- If we vary the tier projection and constraints slightly, we can account for a wide range of variation across languages and constructions.
- This variation is similar to other linguistic phenomena, especially phonological harmony.
- Most of the logical possibilities of the model are realized within a single phenomenon — this is not necessarily expected!

# Some open questions

- Do we ever need a window size larger than 2?

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- Are there patterns that are not TSL under any reasonable analysis?
- How far can we take the parallel with harmony in phonology?

# Takeaways

- Computational approaches to linguistic analysis reveal insights that might otherwise not be obvious.

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- Computational approaches to linguistic analysis reveal insights that might otherwise not be obvious.
- In other cases, they provide independent support to conclusions reached in other ways (e.g. visibility is parameterized).
- A clear understanding of the formal patterns can help us understand other aspects of linguistic structure.

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## Extras

Even more on TSL

Some formal details

More on locality

Computational considerations

# Extra example: Sibilant harmony

Sibilants match in anteriority, *t* blocks harmony, other C's transparent

(based on Slovenian)

| | |
|---|---|
| All elements: | {s, ʃ, t, k, a} |
| Tier elements: | {s, ʃ, t} |
| Constraints: | {*sʃ, *ʃs} |

| Word | Tier | |
|---|---|---|
| s a s a s a | s s s | ✓ |
| s a **s** a **ʃ** a | s **s** **ʃ** | ✗ |
| s a k a s a | s s | ✓ |
| **s** a k a **ʃ** a | **s** **ʃ** | ✗ |
| s a t a s a | s t s | ✓ |
| s a t a ʃ a | s t ʃ | ✓ |

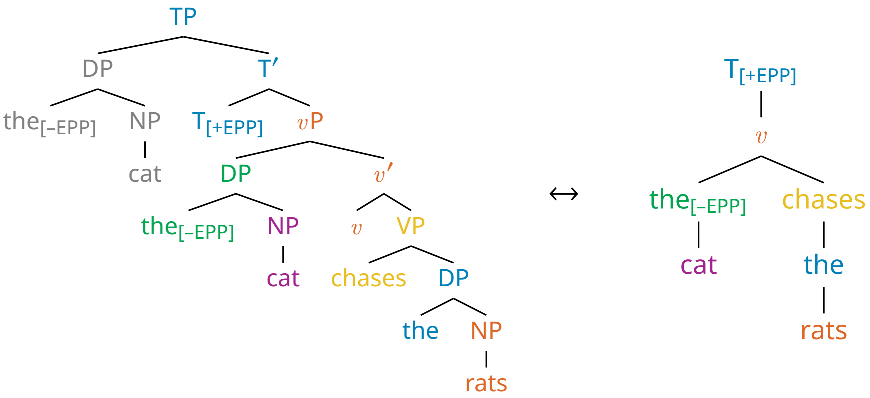
# TSL string languages – formal definition

In a **tier-based strictly *k*-local (TSL-*k*)** language, a string is well-formed iff its **tier projection** does not contain any forbidden substrings of some length $k$.

- $\Sigma$ = "alphabet" = set of all symbols
- $T$ = "tier alphabet" = set of visible symbols
- $G$ = "grammar" = forbidden substrings
- The tier projection is obtained by deleting all non-tier elements and concatenating the remaining elements.

# MG derivation trees

- All nodes appear in base position.
- The rightmost child of a node is its complement; others are specifiers.
- Movement is indicated using feature diacritics.




See Graf and Kostyszyn (2021) for a formal definition. Related: Brody (2000).

# Command strings

A **command string** (c-string) is a derivational ordering of nodes.

- There is a c-string from the root to each node.
- Among each head and its arguments: Head < Specifier < Complement.

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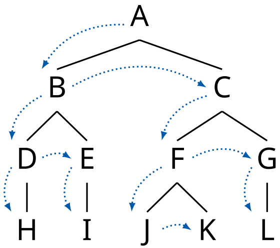


See Graf and Shafiei (2019) for details.

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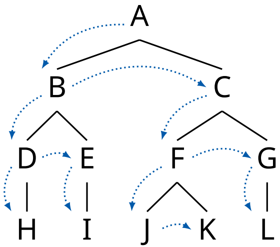


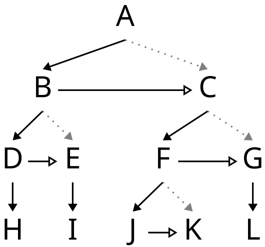


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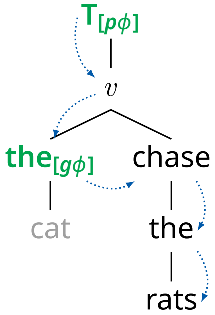
# Tiers over command strings

✓ The cat **chases** the rats. (subject agreement)



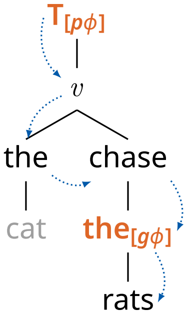

$\longrightarrow$ $\mathbf{T}_{[p\phi]} \cdot v \cdot \mathbf{the}_{[g\phi]} \cdot \text{chase} \cdot \text{the} \cdot \text{rats}$

$\downarrow$

$\mathbf{T}_{[p\phi]} \cdot \mathbf{the}_{[g\phi]} \cdot \text{the}$

# Tiers over command strings (2)

✗ The cat **chase** the rats. (object agreement)



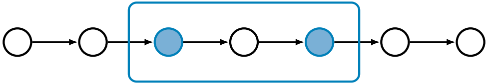

$\longrightarrow$ $\mathrm{T}_{[p\phi]} \cdot v \cdot \mathrm{the} \cdot \mathrm{chase} \cdot \mathrm{the}_{[g\phi]} \cdot \mathrm{rats}$

$\downarrow$

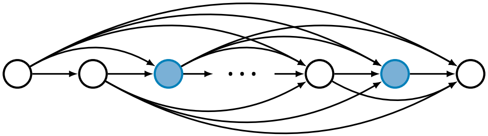
$\mathrm{T}_{[p\phi]} \cdot \mathrm{the} \cdot \mathrm{the}_{[g\phi]}$

# Three models of locality

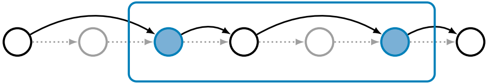
## Immediate precedence (SL)



## General precedence (SP)



## Tier precedence (TSL)



# Three models of locality (2)

- The immediate precedence (SL) model can handle local spreading.
- The general precedence (SP) model can handle unbounded processes, but can't handle blockers.
- Only the tier precedence (TSL) model can handle unbounded processes with blocking.

# Limits on structural configurations

TSL computations can relate elements at a distance, but are otherwise severely restricted in what they can do.

- No arbitrary logic — “a DP can A-move out of a finite CP, but only if there is A′-movement within some (other) CP in the sentence”
- No counting — “up to three reflexive pronouns may occur in a sentence if each obeys the Binding Theory”

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These characteristics derive from the restriction that all constraints must be stated within the moving window.

# Conditions for efficient learning

- The restrictions on TSL patterns help to make them efficiently learnable by limiting the amount of memory needed (Lambert et al. 2021).
- But there are too many possible tiers to test them all individually.
- We also need to consider other aspects of language acquisition such as the Tolerance Principle (see eg. Belth 2023; Hanson 2024b).