

# Mathematical Comparison of Linguistic Categories without Universal Spines

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# Mathematical Comparison of Linguistic Categories

- **Preliminaries**
- Against a Universal Spine
- A model of asymmetric Extended Projection Comparison
- Potential applications and predictions of the model

# Preliminaries - Against Innate Categories

- Psychological Plausibility
- Increasing number of necessary categories
- Variation in formal properties of attested Categories

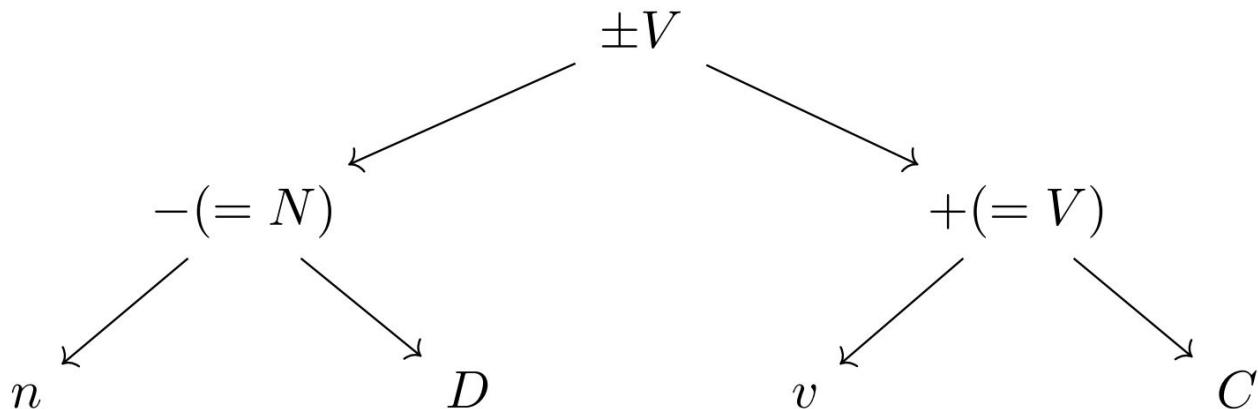
# Preliminaries - Against Innate Categories

Plural Marking	English	Halkomelem
absence of plural marking = singular	yes	no
obligatory agreement	yes	no
plural can be selected for (pluralia tantum)	yes	no
form-meaning mismatches	yes	no
complementarity with classifiers	yes	no
bare plurals can be arguments	yes	no
restricted to nouns	yes	no
can occur inside compounds	no	yes
can occur inside derivational morphology	no	yes

(Wiltschko  
2008, Table 6)

# Preliminaries - Maximise Minimal Means

- Biberauer & Roberts 2015 and following
- The child postulates categories as a response to departures from Saussurean form-meaning arbitrariness in the linguistic data
- Radically Impoverished UG



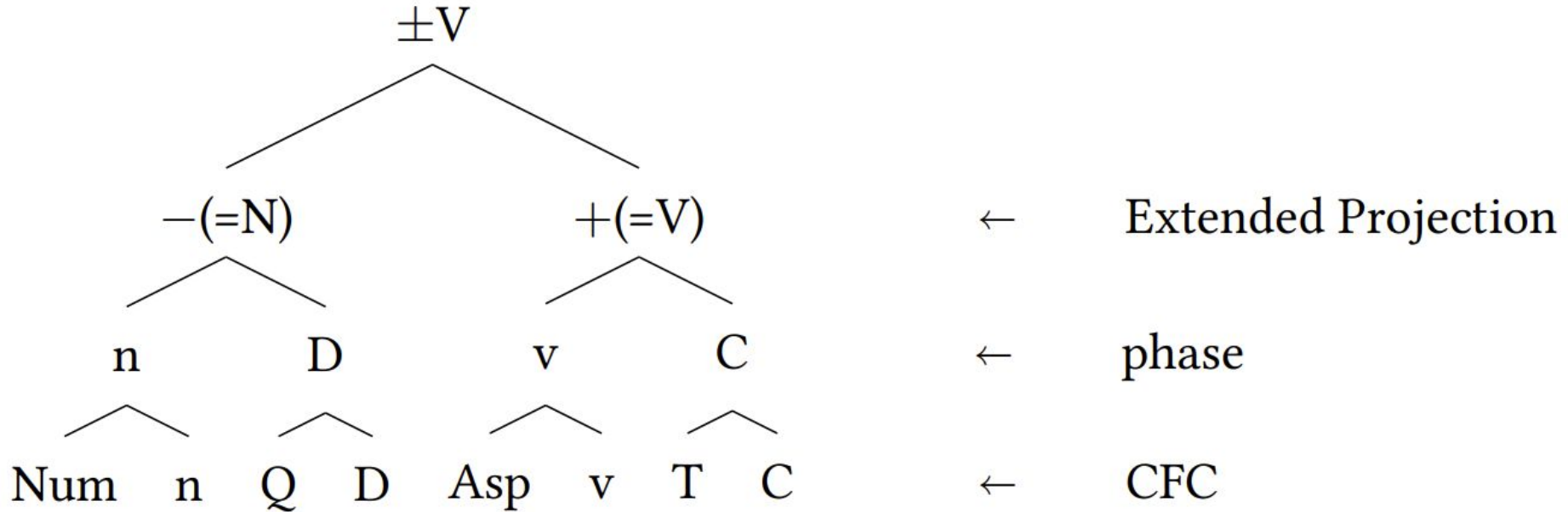
# Preliminaries - Extended Projections

- Extended Projections (Grimshaw 1991) (EPs) refer to a lexical head and its related higher functional heads.
- There are many proposals for the number and structure of these in individual languages.
- Eg. Verbal, Nominal - references in Evans & Levinson 2009
- Adjectival?, Prepositional?
- Mixed Extended Projections? (Borsley & Kornflit 2000)
- Importantly, we do not want to assume that EPs must contain the same number of categories (eg. polysynthesis)

# Preliminaries - Relations between sets of categories

- It is useful, and should be expected if we are making use of third factors, for there to be similarities in the structures of sets of categories.
- There are many examples of this in the literature but they are often conflicting.
- Assuming innate categories it is easy to see how these would arise, but this is not trivial with Maximise Minimal Means.

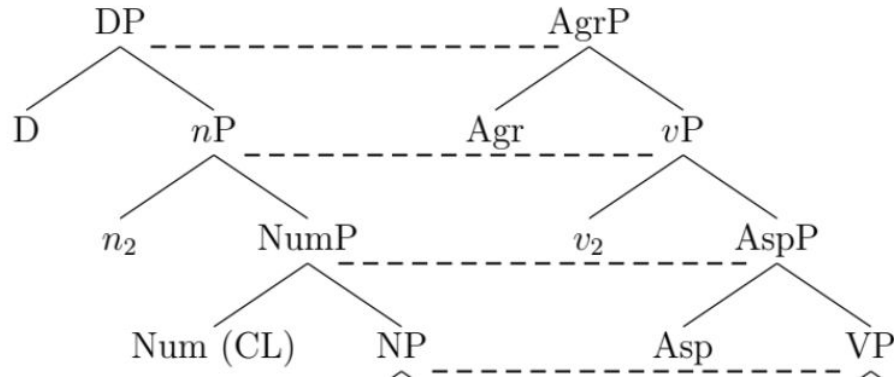
# Preliminaries - Relations between sets of categories



(Biberauer 2017, (23))



# Preliminaries - Relations between sets of categories

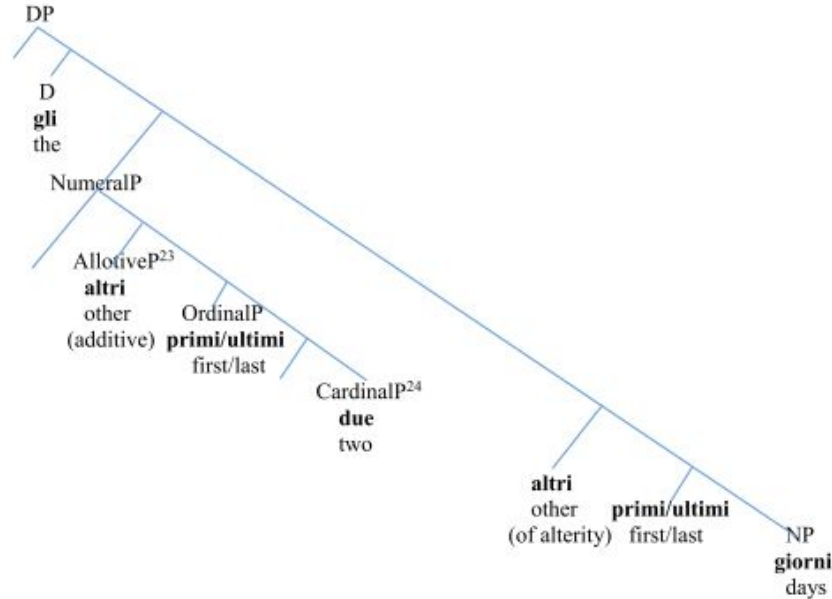


(Megerdooomian 2008, (42))

[CP C [TP T [vP v [VP V ]]]]  
 [DP D [NumP Num [nP n [NP N ]]]]  
 discourse inflection thematic

(Li9 Lecture 5, (21))

# Preliminaries - Relations between sets of categories



(Cinque 2022, (29))

# Preliminaries - Universal Spines

Wiltschko (2014) notes facts similar to what we have seen (43):

- a. There is evidence for the universality of categories
- b. Languages vary in their categorial inventories

# Preliminaries - Universal Spines

Wiltschko suggests that there is a cognitive Universal Spine that language specific categories can associate with according to a number of parameters.

- Timing
- Location
- Valuation

**(49) Discourse Linking > Anchoring > Point-of-view > Classification**

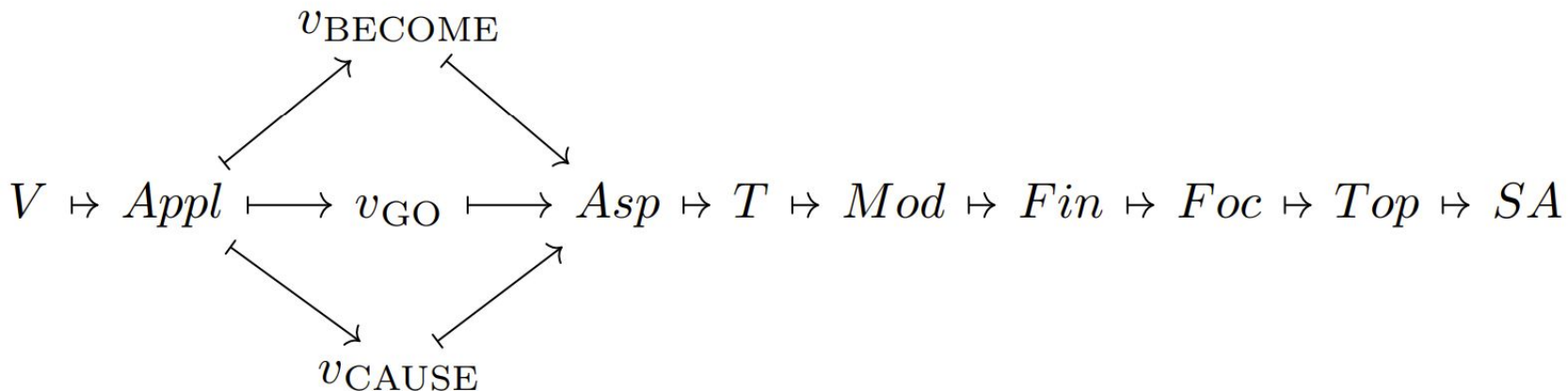
# Preliminaries - Mathematics of comparison

- We can view an EP as a partially ordered set (poset)
- For every two elements  $(a, b)$ , there may be the relation  $(a \leq b)$ ,  $(b \leq a)$ , or no relation.
- If every pair of elements has a relation, this is a total order
- This relation has the following properties:
  - Reflexivity  $(a \leq b)$  - every element is related to itself
  - Antisymmetry - if  $(a \leq b)$  and  $(b \leq a)$  then  $(a = b)$
  - Transitivity - if  $(a \leq b)$  and  $(b \leq c)$  then  $(a \leq c)$

# Preliminaries - Mathematics of comparison

- Cartographic EPs are generally totally ordered
- Partial orders are used for flavoured heads, which have been argued for by some works in distributed morphology (eg. Cuervo 2003)

VEP  $V \mapsto Appl \mapsto v \mapsto Asp \mapsto T \mapsto Mod \mapsto Fin \mapsto Foc \mapsto Top \mapsto SA$



# Preliminaries - Mathematics of comparison

- Category theory generalises concepts from other fields of mathematics.
- A category consists of objects, morphisms (generalisation of functions) and a binary operation for composing morphisms.
- For our EPs, the objects are each individual element, the morphisms are the  $\leq$  relation.
- The composition operation preserves reflexivity and transitivity.

# Preliminaries - Mathematics of comparison

- We can abstract back a layer and view entire EPs as objects
- We are looking for functors between EPs which preserve the internal structure of objects and morphisms.

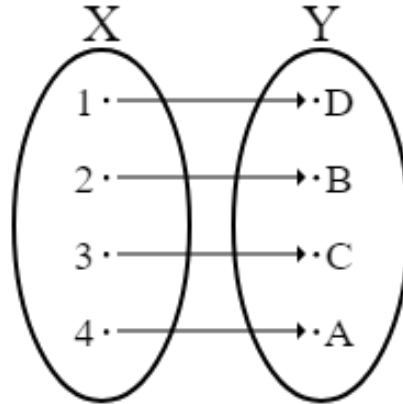
VEP      $V \mapsto Appl \mapsto v \mapsto Asp \mapsto T \mapsto Mod \mapsto Fin \mapsto Foc \mapsto Top \mapsto SA$

NEP      $N \mapsto Gen \mapsto n \mapsto Cl \mapsto Num \mapsto Q \mapsto Det \mapsto K$



# Preliminaries - Mathematics of comparison

- The strongest forms of comparison between posets are equivalence and isomorphism.
- These correspond to bijections (also known as inverse functions or one-to-one mappings).
- As we have said that EPs need not have the same number of elements, this is automatically ruled out.

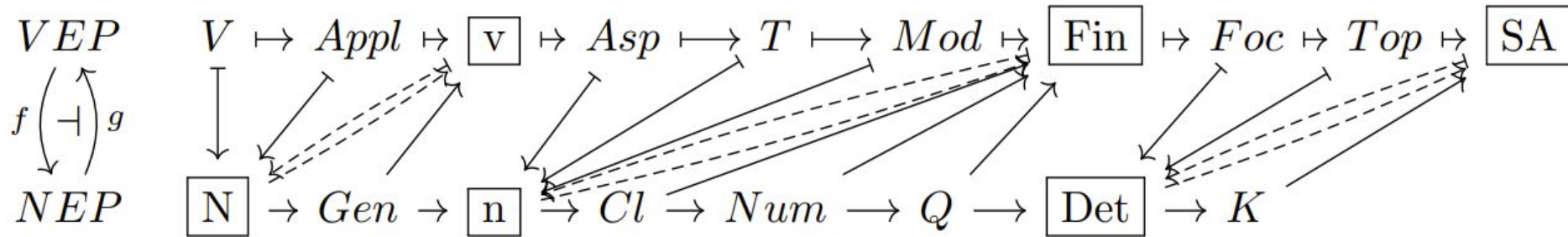


# Preliminaries - Mathematics of comparison

- A weaker form of comparison is called an Adjunction in category theory (nothing to do with linguistic adjunction).
- Uniqueness up to isomorphism.
- For posets, this takes the form of a Galois connection.
- For posets  $A$  and  $B$ , a galois connection is a pair of order reversing functions  $f: A \rightarrow B$  and  $g: B \rightarrow A$  such that  $f(a) \leq b$  if and only if  $a \leq g(b)$ .
- In simple terms, after a round trip between functions,  $a$  can only increase or stay the same, whereas  $b$  can only decrease or stay the same.
- $f$  is the left (lower) Adjoint function and  $g$  is the right (upper) Adjoint.

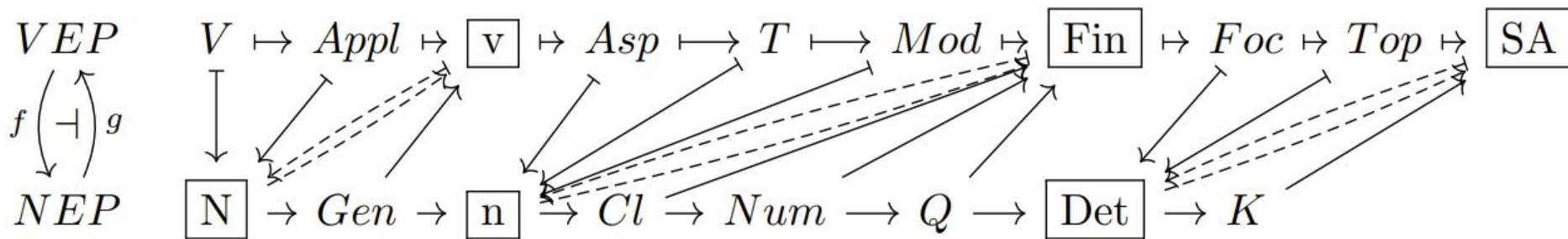
# Preliminaries - Song 2019

- Song attempts to formalise a comparison between emergent EPs making use of an Adjunction.
- This suggestion (pg. 214) has no problems mathematically.



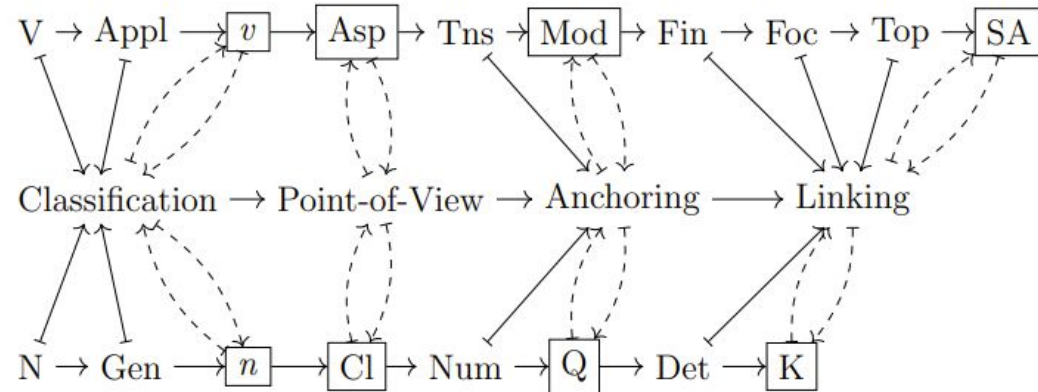
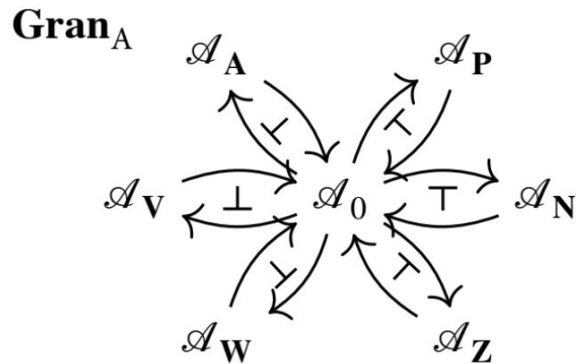
# Preliminaries - Song 2019

- However Song rejects this potential Adjunction on linguistic grounds:
- This adjunction applies asymmetrically between EPs.
- There is an unintuitive skewing of conventionally equivalent categories like V and N.
- More broadly, for every two EPs, the highest element of one and the lowest element of the other have a special status which needs motivating.
- The mathematics of Adjoint functions does not seem to apply here.



# Preliminaries - Song 2019

- Song (whose dissertation is far more broad than just this matter) concludes that the optimal linguistic Adjunction makes use of a Universal Spine to mediate between EPs (pg. 218).
- This US can mediate between more than two EPs, and has fewer elements than EPs.



# Preliminaries

- We want to minimise what is considered innate, as far as is reasonable in linguistic theory.
- If we can maintain a mathematically and linguistically meaningful comparison between EPs without a mediating Universal Spine, this would be an interesting path for research.
- This doesn't mean that Universal Spines are not useful for certain research questions.

# Mathematical Comparison of Linguistic Categories

- Preliminaries
- **Against a Universal Spine**
- A model of asymmetric Extended Projection Comparison
- Potential applications and predictions of the model

# Against a Universal Spine - Theoretical Considerations

- Many different approaches for what can be considered functionally Universal (although Song requires multiple Universal Spines for different granularity levels).
- Universal Spines cannot be explicitly disproven as their theoretical status as psychologically/linguistically real objects is unclear.

# Against a Universal Spine - Spoken Languages

- Expressive Morphology
- Linking of functional projections to Linking/Anchoring/Point-of-view
- Eg. Determiners - I or C properties, what about languages which don't have determiners or have them behave like other elements?



# Against a Universal Spine - Sign Languages

- To achieve complete coverage, a Universal Spine should be modality independent.
- Sign languages can make use of simultaneity and spatial relations more easily than spoken languages.
- Wiltschko's US: Discourse Linking > Anchoring > PoV > Classification
- Should it be the null hypothesis that this information is processed cognitively the same in vision as for speech?

# Against a Universal Spine - Sign Languages

- Sign languages do support basic equivalences with the basic tripartite division of VP - TP - CP (Pfau et al. 2018).
  - Agreement Verbs, or agreeing auxiliaries, have been argued to correspond to TP categories - with possible differences in Word Order (Proske 2022)
  - Question words are found at peripheries of clauses as expected for C elements, but can be to the right - with the help of non-manual marking throughout (Cecchetto 2009).
- An interesting cartographic proposal - hierarchy maps onto the height that elements are articulated at (Bross 2020)

# Against a Universal Spine - Sign Languages

- One of the key arguments of Wiltschko 2014 is that Tense is not a universal category, and languages may display other elements in the anchoring domain.

English	Blackfoot	Halkomelem	Upper Austrian German
Tense	Person	Location	Realis

- Sign languages use location to anchor events - necessarily due to the modality.
- Could a sign language use another category, and is there a principled way to distinguish location in anchoring from other uses of spatial articulation?

# Against a Universal Spine - Sign Languages

- Types of verbs in German Sign Language - body-anchored plain verbs, neutral plain verbs, agreement verbs, agreeing auxiliaries (Bross 2020).
- This can have effects of preferred word order

# Against a Universal Spine - Sign Languages

Manual and  
non-manual use of  
space in the lexicon



# Against a Universal Spine - Sign Languages

Combination of  
noun and number



# Against a Universal Spine - Psychology

- Hard to interpret psychological and neurological evidence given granularity problem (Poeppel & Embick 2017).
- But psycholinguistic findings don't support the existence of a Universal Spine.
- Different brain responses to noun vs verb, functional vs lexical, but not Universal Spine categories.
- Can Neo-Emergentism be used in modelling atypical acquisition?

# Against a Universal Spine - Psychology

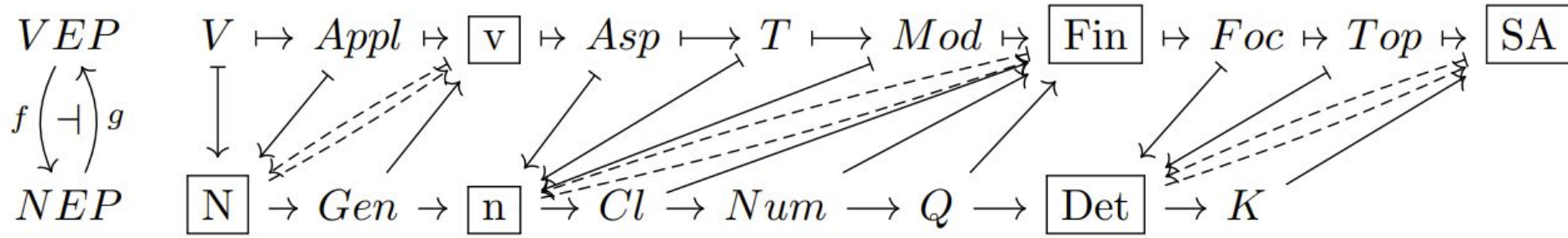
- Deficit in tense and aspect marking in autistic children (Chen et al. 2023, Barlotucci 1974)
  - Weak central coherence hypothesis? (Brock et al. 2002)
  - Difficulties in integrating information from different specialised brain networks.
  - Inhibits temporal binding of composite information.
  - View larger objects as collection of parts rather than a whole



# Mathematical Comparison of Linguistic Categories

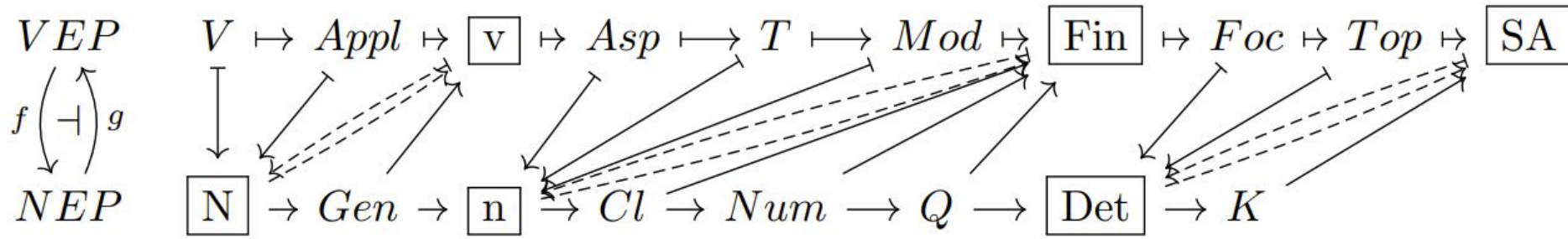
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- **A model of asymmetric Extended Projection Comparison**
- Potential applications and predictions of the model

# Extended Projection Comparison



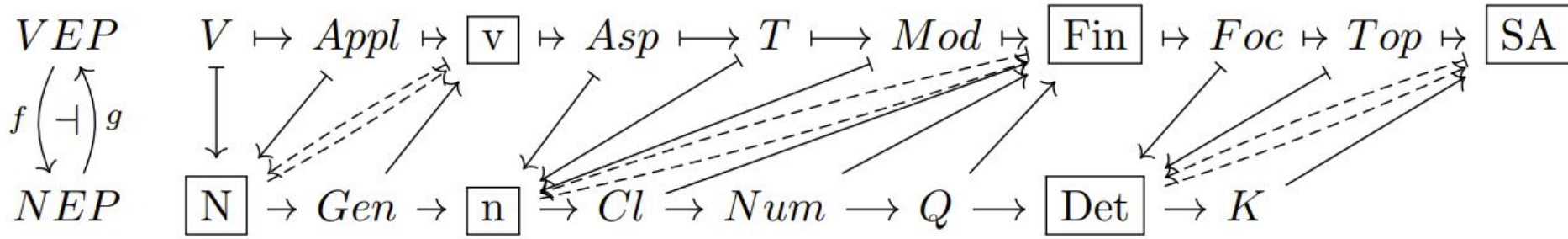
- **Asymmetry of entire EPs**
- Asymmetry between individual core categories
- Maths of Adjunction

# Extended Projection Comparison - Asymmetry of EPs



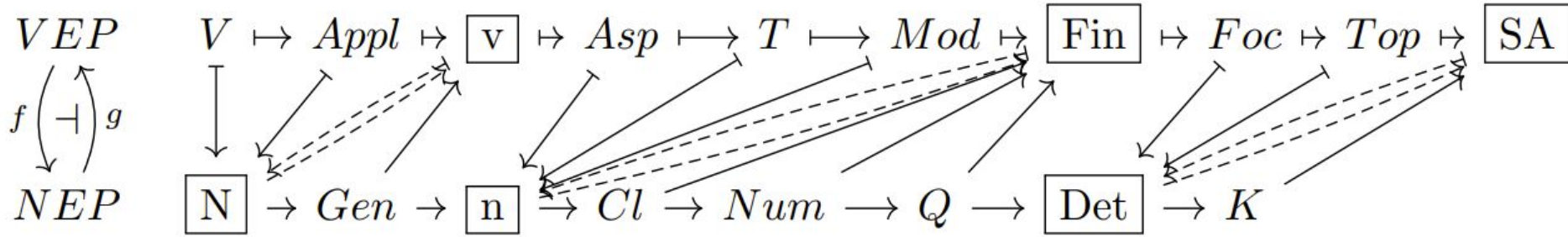
- There are asymmetries between the N and V in acquisitional (Gentner 1982, Tardif 1996) and semantic (NP vs (S\NP)/NP in Combinatory Categorical Grammars) domains.
- In Mixed Extended Projections, whole EPs seem to be asymmetrical
- If there are also Adjectival, Adpositional etc. EPs, symmetry seems harder to maintain.

# Extended Projection Comparison



- Asymmetry of entire EPs
- **Asymmetry between individual core categories**
- Maths of Adjunction

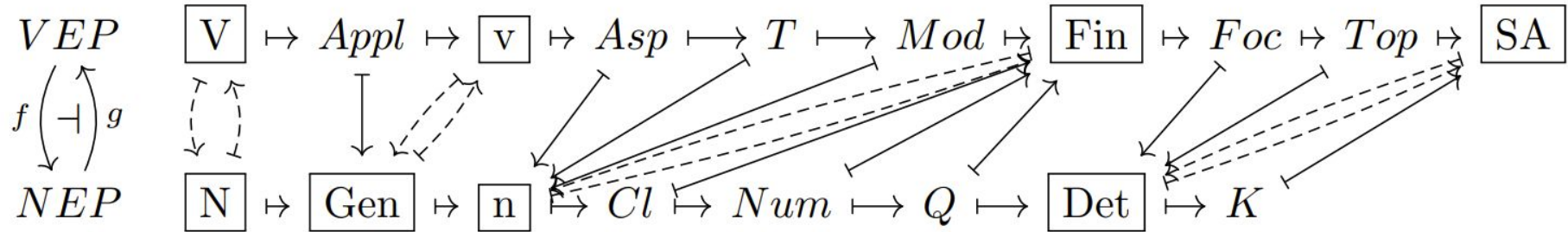
# Extended Projection Comparison - Element Asymmetry



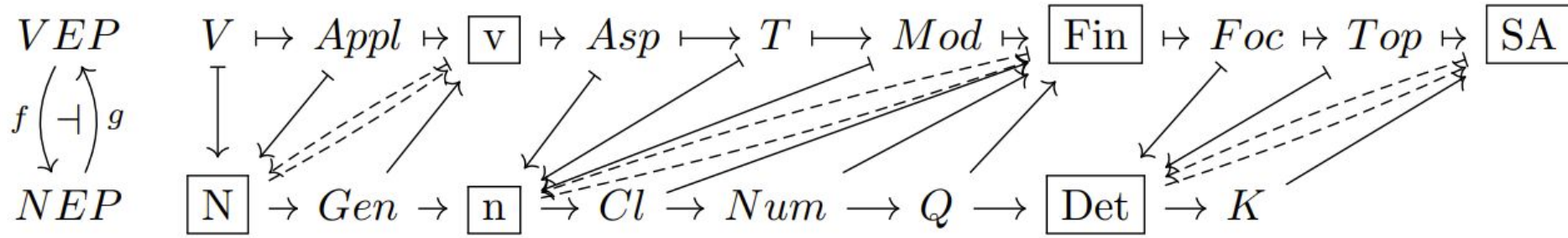
- For most categories, 'asymmetries' are arbitrary seeing as there is debate as to which categories should be peripheral
- At the edges, not all categories seem similarly salient - top of NEP is variously Determiner (Biberauer, 2019), Case (K) (Bittner and Hale, 1996), Quantifier (Shlonsky, 1991), Classifier (Cheng and Sybesma, 1998), or various other heads (Corver, 2013)

# Extended Projection Comparison - Element Asymmetry

- There is a stronger argument that lexical items should be symmetrical, which is possible in this model



# Extended Projection Comparison



- Asymmetry of entire EPs
- Asymmetry between individual core categories
- **Maths of Adjunction**

# Extended Projection Comparison - Adjunctions

**Example 6.3.3.2** (Spivak 2014). Let  $\mathcal{A}$  be the Category of an adult's words (i.e., sound-meaning pairs) and  $\mathcal{B}$  be the Category of a baby's noises (i.e., sounds without meanings). The “translation” between baby language and adult language can be viewed as an Adjunction, with the left adjoint  $F : \mathcal{B} \rightarrow \mathcal{A}$  mapping the baby's noises to free words that pair a sound with a meaning placeholder  $\mu$  and the right adjoint  $U : \mathcal{A} \rightarrow \mathcal{B}$  mapping an adult word to its sound part by forgetting its meaning. This yields a pair of free and forgetful Functors, pictorially

$$\begin{array}{ccc}
 \mathcal{B} & \begin{array}{c} \xrightarrow{F=\langle -, \mu \rangle} \\ \perp \\ \xleftarrow{U} \end{array} & \mathcal{A} \\
 B & \xrightarrow{F(B)} \langle B, \mu \rangle & \\
 \downarrow f & \Downarrow & \downarrow g \\
 A & \xleftarrow{U(\langle A, \mu_A \rangle)} \langle A, \mu_A \rangle & .
 \end{array}$$

(from Song  
2019, pg.  
205)

The hom-set bijection can be understood as the adult's deciphering of the baby's noises by matching the free words against the correct words (by comparing sounds) and the baby's acquisition of pronunciation by emulating the sounds of adult words.



# Extended Projection Comparison - Adjunctions

- Left Adjoints are typically associated with adding some (free) structure.
- They can be seen as the most efficient solution to some problem.
- Does this apply here?

# Mathematical Comparison of Linguistic Categories

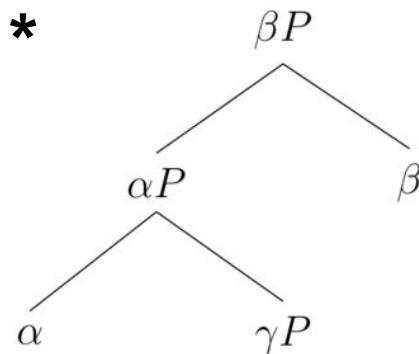
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# Potential Applications - Maximise Minimal Means

- Adjunctions could be used to model emergent many-to-one phenomena in linguistic data
- Languages are filled with examples which can be modelled as an order-preserving relation between two posets (although where these posets arise from is not trivial)

# Potential Applications - Maximise Minimal Means

- Final-over-Final Condition



- Relation between EP and linearisation poset (eg. left  $\leq$  right )
- Rollup - English  $\leq$  'Leaking OV'  $\leq$  German  $\leq$  Japanese

# Potential Applications - Maximise Minimal Means

## Mixed Extended Projections

- German:

[<sub>CP</sub> dass<sub>C</sub> ich [<sub>TP/VP</sub> [<sub>DP</sub> den<sub>D</sub> Mann] sehe.<sub>T/V</sub> ]]

‘That I see the man.’

- Buli (Hiraiwa 2005, cited in Hein & Murphy 2022)

dε mángò-kú-lá

ate mango-dem-def

‘ate that mango’

mángò-kú dε-kā

mango-dem eat-nmlz

‘eating the mango’

# Potential Applications - Maximise Minimal Means

Pesetsky 2013 - certain Russian nouns can show patterns of mixed masculine and feminine agreement.

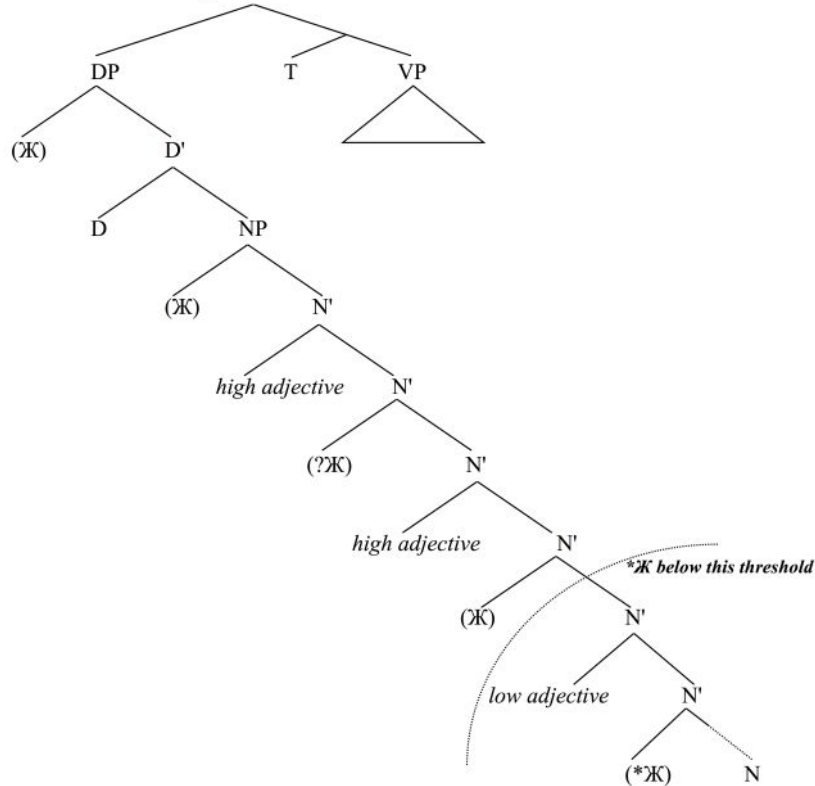
- Nov-yj vrač-∅ prišla-∅.  
new-M.NOM.SG doctor-NOM.SG arrived-F.SG  
The new doctor arrived. (26b)
- \*Nov-aja vrač-∅ prišël-∅.  
new-F.NOM.SG doctor-NOM.SG arrived-M.SG  
The new doctor arrived. (26c)
- Glavn-yj/\*Glavn-aja vrač-∅ poliklinik-i skazal-a, čtoby...
- head-M/\*F.NOM.SG doctor-NOM.SG clinic-GEN.SG say-PST.F.SG  
that.SUBJ...  
'The (female) head doctor of the clinic ordered that...' (27a)

# Potential Applications - Maximise Minimal Means

- U nas byl-a očēn' xoroš-aja zubn-oj vrač-∅.  
by us COP-PST.F.SG very good-F.NOM.SG dental-M.NOM.SG  
doctor-NOM.SG  
'We had a very good (female) dentist.' (28b) (Skoblikova, 1971, pg.183)
- ?U menja očēn' interesn-aja nov-yj vrač-∅.  
by me very interesting-NOM.F.SG new-NOM.M.SG doctor-NOM.SG  
'I have a very interesting new (female) doctor.' (29a)
- \*\*U menja očēn' interesn-yj nov-aja vrač-∅.  
by me very interesting-NOM.F.SG new-NOM.M.SG doctor-NOM.SG  
'I have a very interesting new (female) doctor.' (29b)

## Potential Applications - Maximise Minimal Means

### Possible merge sites for $\mathcal{K}$



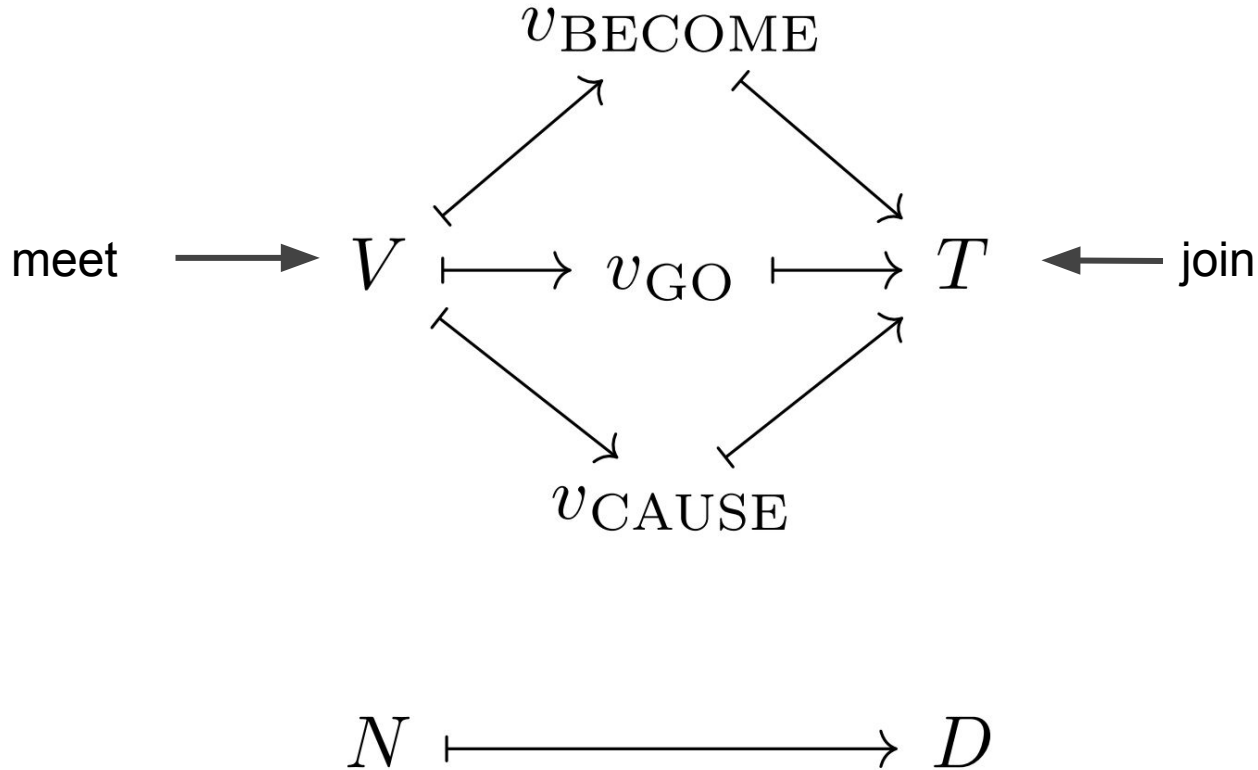
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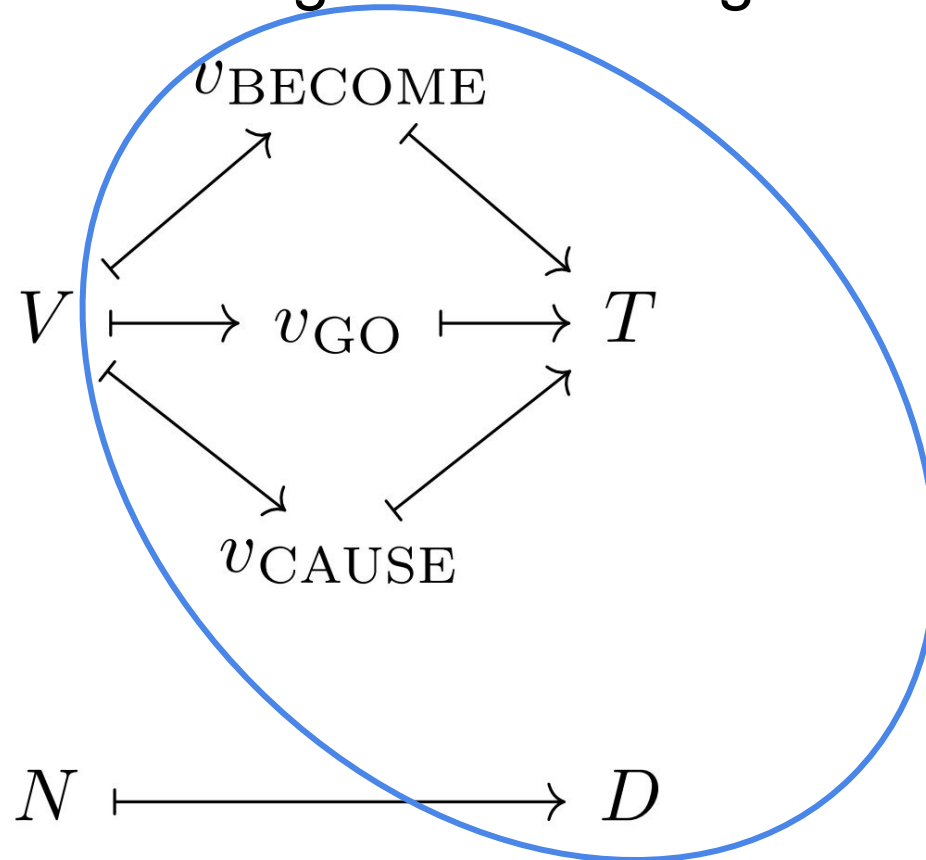
# Potential Applications - Maximise Minimal Means

- We might be able to account for diachrony and acquisitional stages
- Large domains - can we model granularity and acquisitional ordering of functional categories (Bosch 2023)
- Borrowing, multifunctionality and diachrony - many hierarchies have been proposed for these - can we make predictions?

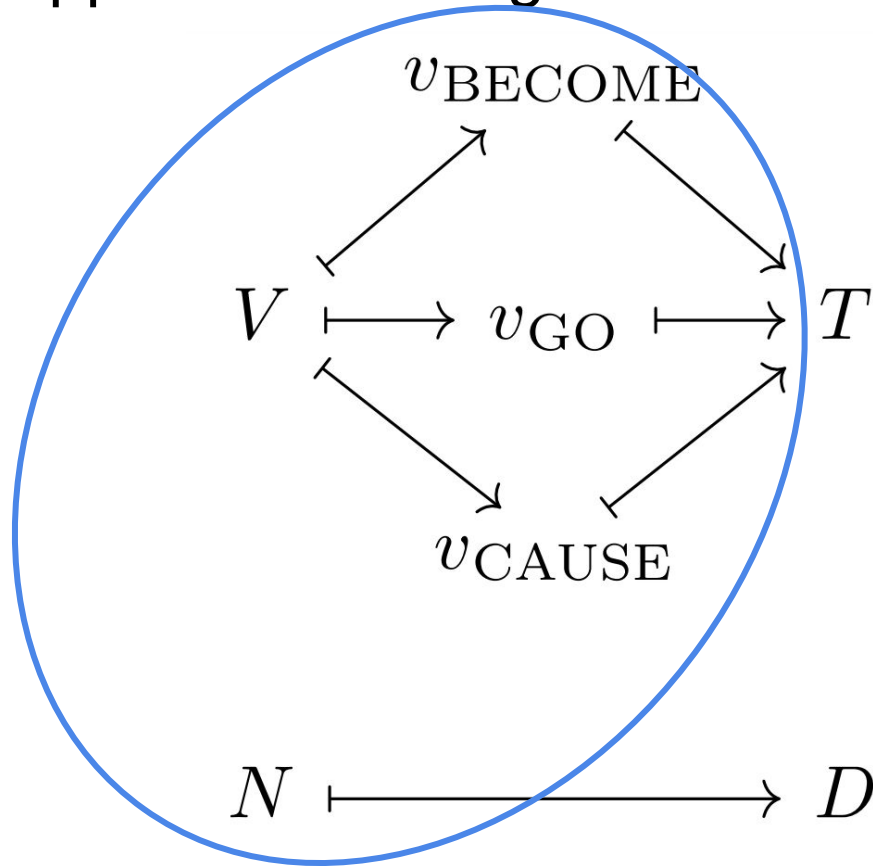
# Potential Applications - Edges and Acategorical Elements



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# Potential Applications - Edges and Acategorical Elements

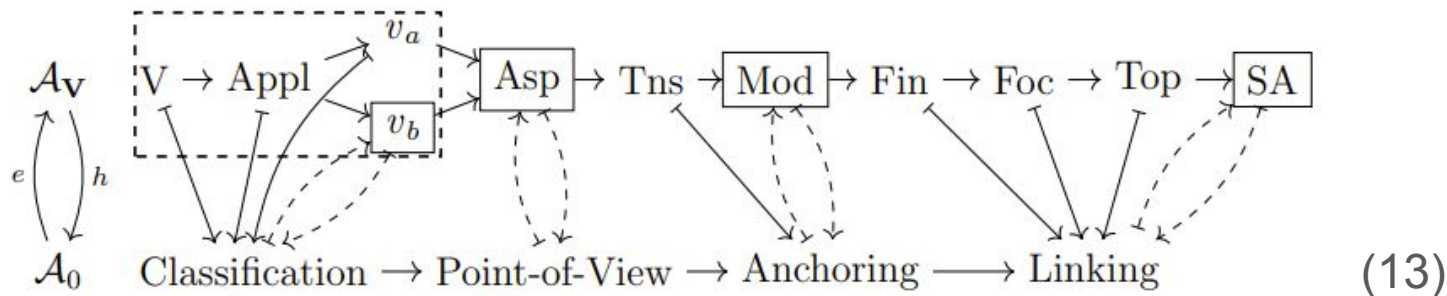


# Potential Applications - Edges and Acategorical Elements

- Left Adjoints preserve joins
- Right Adjoints preserve meets

# Potential Applications - Edges and Acategorical Elements

- Song (2020) derives the following theorem from his model.
- “In phase-based minimalism, no phase head can be flavored.”
- Left Adjoints preserve joins (maximums), right Adjoints preserve limits (minimums)



# Potential Applications - Edges and Acategorical Elements

- Flavoured or otherwise not-totally ordered categories cannot arise at certain points in the Adjunction - different in this model than to Song's.
- The model here might not be useful for phases due to the differing cardinalities of EPs.
- Dynamic Phases?

# Potential Applications - Edges and Acategorical Elements

- Sentence final particles can cover a wide range of semantic information - aspect, discourse, negation, interrogatives.
- This might present a challenge for Universal Spines.
- Emojis?

Tā chī-le fān **le**.

3SG eat-PERF food PERF

'He has eaten' (Paul 2014, pg. 86)



# Potential Applications - Edges and Acategorical Elements

- They don't behave as a uniform class and have received many different treatments.
  - They might arise only at certain points in phases (Erlewine 2017)
  - Or be heads separate from derivational spine (Song 2019)
- Biberauer (2017) argues that they do not belong to the Verbal EP.
- These elements can be easily borrowed, and can have particular phonological and semantic characteristics.
- This does not suit a Universal Spine approach.
- Their attachment to the edge of differing EPs is not unexpected in this model.

References on handout