Alternative Questions in Urdu: From the Speech Signal to Semantics

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(including joint work with Benazir Mumtaz)

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Larger Context

- Part of a Research Unit (FOR 2111) *Questions at the Interfaces* at Konstanz
  - Looking at non-canonical uses of questions across languages
  - Butt, Bögel and Mumtaz represent Project P4, working specifically on Urdu/Hindi
  - We have a cooperation with María Biezma (Project P2, looking at Romance).
- Generally trying to understand the interplay between **prosody, morphosyntax** and **semantics/pragmatics** with respect to (non-canonical) questions.

Structure of Talk

This talk:

- analysis and computational implementation of Urdu
  alternative (AltQ) vs. polar questions (PolQ)
- holistic integration of information from the speech signal into a semantic analysis

Observation

As far as we know we are the only theoretical framework that can provide a formal model and computational implementation of the **integration of prosody with morphosyntax and semantics**.

Introduction

- **Prosody:** We build on previous work that extends LFG's analytical abilities to include information coming directly from the speech signal (Bögel 2015, Butt and Biezma 2022).
  - → A modular approach (in keeping with LFG's overall architecture).
  - → Automatic processing of the speech signal to extract grammatically relevant information that can then be accessed by other modules of grammar (e.g., syntax or semantics) (Bögel and Zhao 2024).

Introduction

- **Syntax:** We generally follow the architecture and analyses established within the Urdu ParGram project (e.g., Butt et al. 1999, Butt and King 2007, Sulger et al. 2013).
- **Semantics and Pragmatics:** We work with the glue semantics workbench (Meßmer and Zymla 2018) and a co-descriptive approach (though description by analysis is a viable alternative).

Structure of Talk

1. Background: Questions in Urdu/Hindi
2. Case Study: Alternative Questions (AltQs) vs. Polar Questions (PolQs)
3. Basic LFG Architecture and Analysis
4. Disambiguation via Prosody
5. Semantic/Pragmatic Analysis
6. Summary: from the Speech Signal to Semantics/Pragmatics with LFG

Polar Questions

- Urdu/Hindi has basic SOV word order.
- Question vs. declarative status is signaled via intonation.

Declarative: Intonational phrase boundary is L-L%

(1) ʃahina=ne norina=ko mara$_{\text{L-L\%}}$
Shahina.F=Erg Norina.F=Acc hit-Perf.M.Sg
'Shahina hit Norina.' (Declarative)

Polar Question: Intonational phrase boundary is L/H-H%

(2) ʃahina=ne norina=ko mara$_{\text{L/H-H\%}}$
Shahina.F=Erg Norina.F=Acc hit-Perf.M.Sg
'Did Shahina hit Norina?' (Polar Question)

Polar Questions

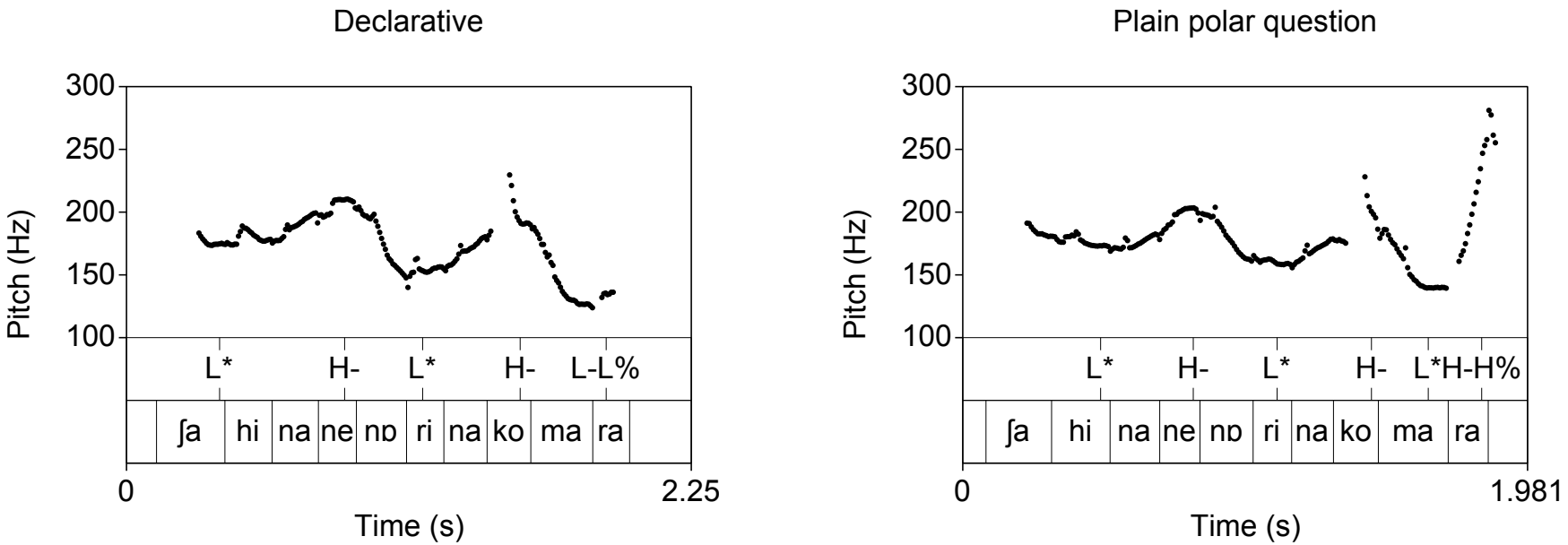


Figure: F_0 contour of a string identical declarative and polar question.

Also note the otherwise general LH pattern on prosodic phrases in Urdu/Hindi.

Alternative Questions

- Urdu/Hindi AltQs can be formed with either *ja* 'or' or *ki* 'that/or'.
- The distribution of *ki* 'that/or' is more restricted than that of *ja* 'or'.
- See, e.g., Han and Romero (2004), Bhatt and Dayal (2020), Biezma et al. (2025).

(3) a. tʃandra=ne kofi p-i ja/ki cai
Chandra.F=Erg coffee.F.Nom drink-Perf.F.Sg or tea.F.Nom
'Did Chandra drink tea or coffee?'

b. tʃandra=ne kofi ja cai p-i
Chandra.F=Erg coffee.F.Nom or tea.F.Nom drink-Perf.F.Sg
'Did Chandra drink tea or coffee?'

Alternative Questions

- A subset of AltQs with *ja* 'or' are string identical with PolQs (as well as declaratives).

(4) t̪ʊm muli ja gobʰi kʰɑo-gi
you radish.F.Nom or cauliflower.F.Nom eat-Fut.F.Sg
AltQ: Will you eat radish or$_{\text{ALT}}$ (will you eat) cauliflower?
PolQ: Will you eat either radish or cauliflower (yes or no)?
Decl.: You will eat either radish or cauliflower.

- Presumably the identification of an AltQ vs. a PolQ is also done via prosodic information.
- However, we have no information at all about the prosody of AltQs.

Structure of Talk

Data

- **Overall Objective:** to test whether AltQs and PolQs differ prosodically.
- Mumtaz and Butt (2024) conducted two production experiments.
  1. Comparing AltQ vs. PolQ production with unambiguous strings.
  2. Comparing AltQ vs. PolQ production with ambiguous strings.
- The results of the two experiments resulted in the same conclusions as to the prosody of PolQs vs. AltQs.
- We here only present the results with respect to the ambiguous strings.
- The unambiguous strings were of the type as in (5).

(5) a. t̪ʊm muli kʰɑo-gi jɑ gobʰi?
you radish.F.Nom eat-Fut.F.Sg or cauliflower.F.Nom
AltQ: Will you eat radish or$_{\text{ALT}}$ (will you eat) cauliflower?

b. t̪ʊm muli kʰɑo-gi?
you radish.F.Nom eat-Fut.F.Sg
PolQ: Will you eat radish?

Data: Ambiguous

- Examples that are string-identical and potentially ambiguous between AltQ and PolQ readings were of the type shown in (6).

(6) t̪ʊm muli jɑ gob^{h}i k^{h}ɑo-gi?
you radish.F.Nom or cauliflower.F.Nom eat-Fut.F.Sg
AltQ: Will you eat radish or$_{\textsf{ALT}}$ (will you eat) cauliflower?
PolQ: Will you eat either radish or cauliflower (yes or no)?

- Such examples can be presented with disambiguating contexts as in (7).

(7) **AltQ Context**: *You are planning to cook dinner. There are only two vegetables in the house: radish and cauliflower and you can only cook one vegetable. Ask your sister what she will eat?*

PolQ Context: *You get up to cook dinner. There are some vegetables available in the house. But you don't know whether your sister will eat those vegetables or not. Ask her:*

Stimuli

- Mumtaz constructed seven pairs of sentences with the same overall structure.
- Each target sentence:
  - begins with the pronoun *t̪ʊm* 'you'
  - ends on the vowel /i/
  - contains bisyllabic CV.CV NPs with stress on the first syllable.
  - Furthermore, all the verbs end with the future morpheme *gi*.

AltQ	**Translation**
t̪ʊm məri dʒɑo-gi jɑ bɑli?	Will you go Murree or Bali?
t̪ʊm pɑni pɪjo-gi jɑ kofi?	Will you drink water or coffee?
t̪ʊm muli kʰɑo-gi jɑ gobʰi?	Will you eat radish or cauliflower?
t̪ʊm lɑri beʧo-gi ja gɑɽi?	Will you sell a lorry or a car?
t̪ʊm gʰɔri mãgo-gi jɑ kʰot̪i?	Will you ask for a mare or a donkey?
t̪ʊm roʈi kʰɑo-gi jɑ boʈi?	Will you eat bread or meat?
t̪ʊm bɑli dekʰo-gi jɑ ʧuɽi?	Will you see an earring or a bangle?

Table: Target sentences for Experiment

Results — For Details see Mumtaz and Butt (2024)

- **F0 Nouns:** N1+Conj has a wider range in AltQs compared to PolQs, suggesting a focus on N1+Conj in AltQs.
- **F0 Verb:** a wider range for V in PolQs, but the absence of an accent on V in AltQs. This is consistent with having the verb be focused in PolQs.

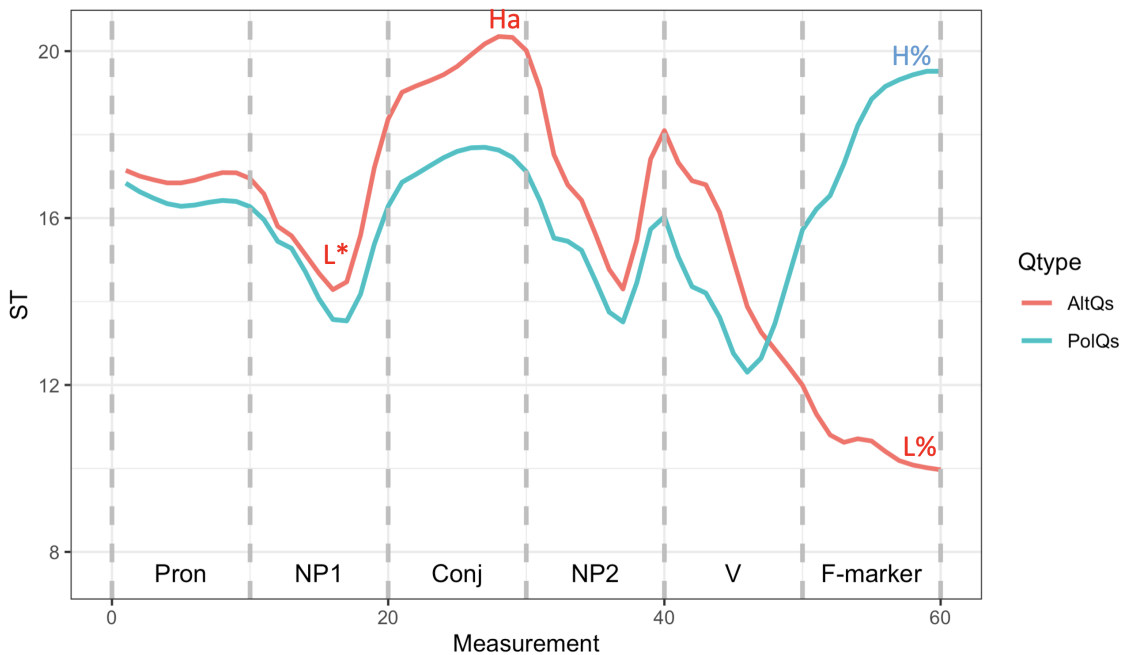


Figure: F0 Contour of string identical AltQs vs. PolQs

Results — For Details see Mumtaz and Butt (2024)

- Boundary Tones:
  - AltQs predominantly have an L% boundary tone.
  - PolQs predominantly have an H% boundary tone.

Table: Distribution of boundary tones in AltQs vs. PolQs

Tones	**PolQs**	**AltQs**
L%	1	135
H%	209	39
HL%	12	50

(This is contra Jabeen (2022), but consistent with Urooj et al. (2019) and Harnsberger (1994)).

Interim Summary and Discussion

- Our results establish that prosodically AltQs are not disjunctions of PolQs.
- Both types of questions generally follow the L*H pattern on prosodic phrases found in Urdu (Harnsberger 1994, Urooj et al. 2019).
- Overall we found that AltQs in Urdu can be identified via four cues:
  - A final fall (L%)
  - A prosodic break between the disjuncts (not shown in the slides)
  - A pitch accent on each disjunct
  - A hat pattern on the first disjunct

$\longrightarrow$ Strings that are ambiguous between an AltQ and a PolQ reading can thus be disambiguated via prosodic means.

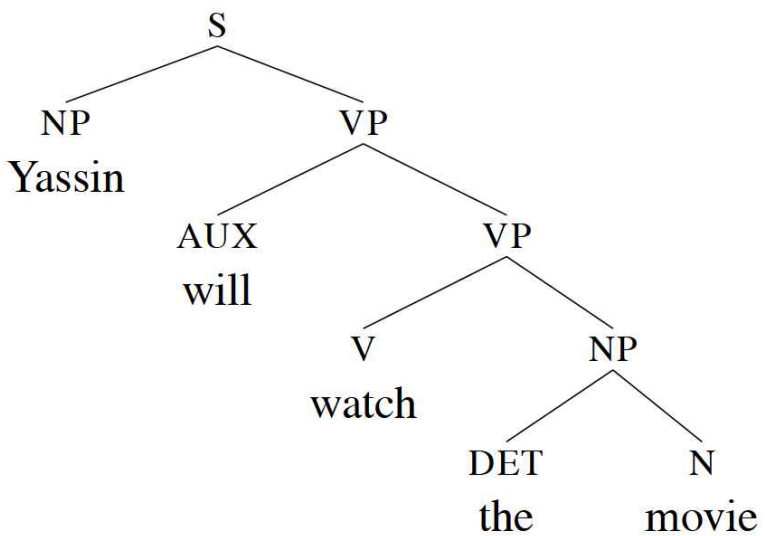
Structure of Talk

Basic LFG Architecture

- There are two syntactic representations in LFG.
  - c(onstituent)-structure: represents linear order, hierarchical relationships and constituency
  - f(unctional)-structure: represents basic predicate-argument relations and functional information
- Below is a simplified analysis (Butt and King 2015).

(1) a. Yassin will watch the movie.

b. **c-structure**



c. **f-structure**

$$\begin{bmatrix} \text{PRED} & \text{'watch<SUBJ,OBJ>'} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{'Yassin'} \end{bmatrix} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{'movie'} \\ \text{SPEC} & \text{the} \end{bmatrix} \\ \text{TENSE} & \text{future} \end{bmatrix}$$

LFG Architecture

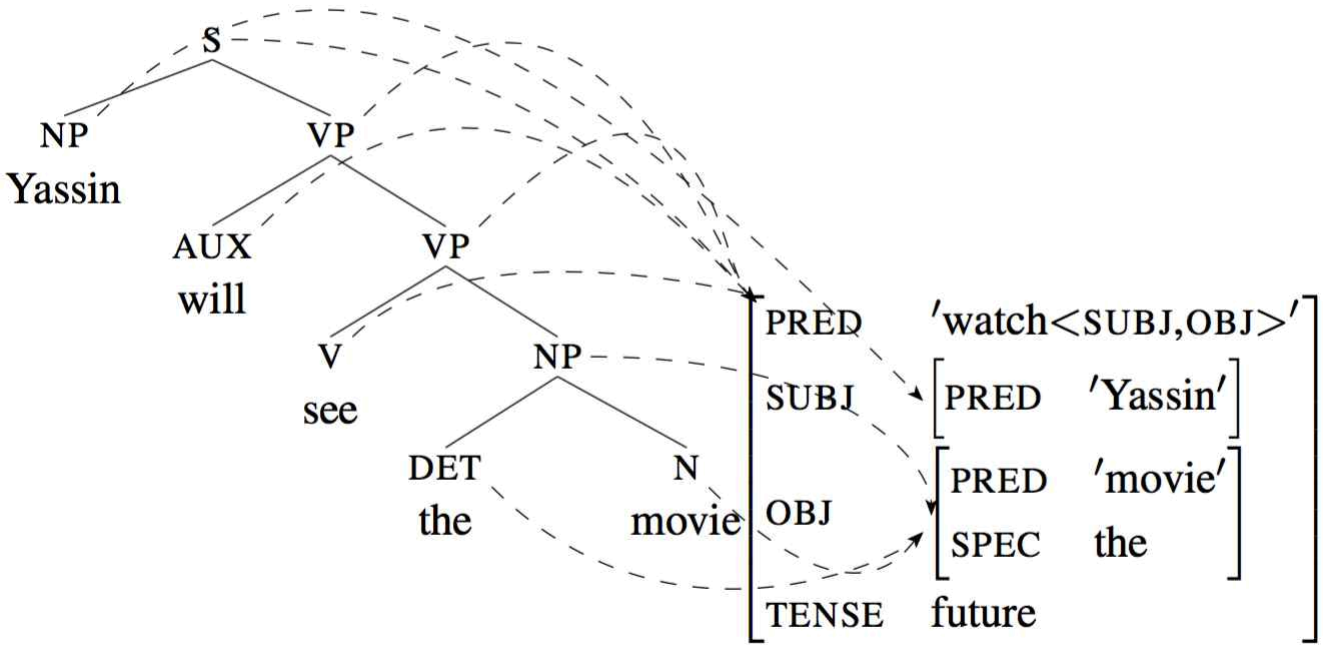
- LFG has a *projection architecture*.
- The different levels of representation are related to each other via mathematically defined projections.
- c-structure and f-structure are related to one another via f-structural annotations on c-structure (the ϕ-projection).

a.	S $\longrightarrow$	NP (↑SUBJ)=↓	VP ↑=↓
b.	VP $\longrightarrow$	AUX (↑TENSE) = ↓	VP ↑=↓
c.	VP $\longrightarrow$	V ↑=↓	NP (↑OBJ)=↓

Projection

- Each piece of the c-structure thus contributes information to the f-structure.

(2) Yassin will watch the movie.



- The f-structure provides the main basis for further semantic analysis.
- Indeed, f-structures have been shown to be equivalent to Quasi Logical Forms, see van Genabith and Crouch (1996).

LFG's Projections

Over the years, more projections than the original core c-structure, f-structure and s(emantic)-structure have been argued for:

- a(rgument)-structure: place for thematic roles and information about predicate composition (complex predicates)
- i(nformation)-structure: place for information structural components (inspired mainly by Vallduví 1992).
- p(rosodic)-structure: place for intonational and prosodic information (Butt and King 1998, Mycock 2006).

The architecture of LFG allows for complex interactions across projections.

Syntax-Prosody Interface

- Initial LFG proposals for the p-structure were "syntactocentric" (cf. Jackendoff 2002).
- Newer proposals have moved to seeing prosody as a separate level of representation that interacts with morphosyntax, but is not derived from it.
- We are basing ourselves on the version proposed by Bögel (2015).
- Computational Implementation:
  - We use XLE (Crouch et al. 2017), the grammar development platform originally built at PARC.
  - All ParGram grammars, including the German grammar developed at the IMS, Stuttgart were written within XLE.
  - See XLE-Web for a publically available interaction with ParGram grammars: https://clarino.uib.no/iness/xle-web.

Syntactic Analysis

- Recall: We are interested in ambiguous sentences of the following type.

(8) t̪ʊm muli jɑ gob^{h}i k^{h}ɑo-gi
you radish.F.Nom or cauliflower.F.Nom eat-Fut.F.Sg
AltQ: Will you eat radish or$_{ALT}$ (will you eat) cauliflower?
PolQ: Will you eat either radish or cauliflower (yes or no)?
Decl.: You will eat either radish or cauliflower.

- The syntax will produce three possible parses for these.
- These three possible parses correspond to three possible semantic readingss.
- The three readings can be disambiguated via prosodic information.

Syntactic Analysis

- The logic of LFG dictates that all three possibilities correspond to just one c-structure (modelling linear order, hierarchies and constituency).
- This one c-structure corresponds to three different f-structures.
  1. A declarative
  2. A polar question
  3. An alternative question
- The three different f-structures can be visualized/represented in one **packed representation** (Emele and Dorna 1998).

Demo

live demonstration of the syntactic analysis

Syntactic Analysis

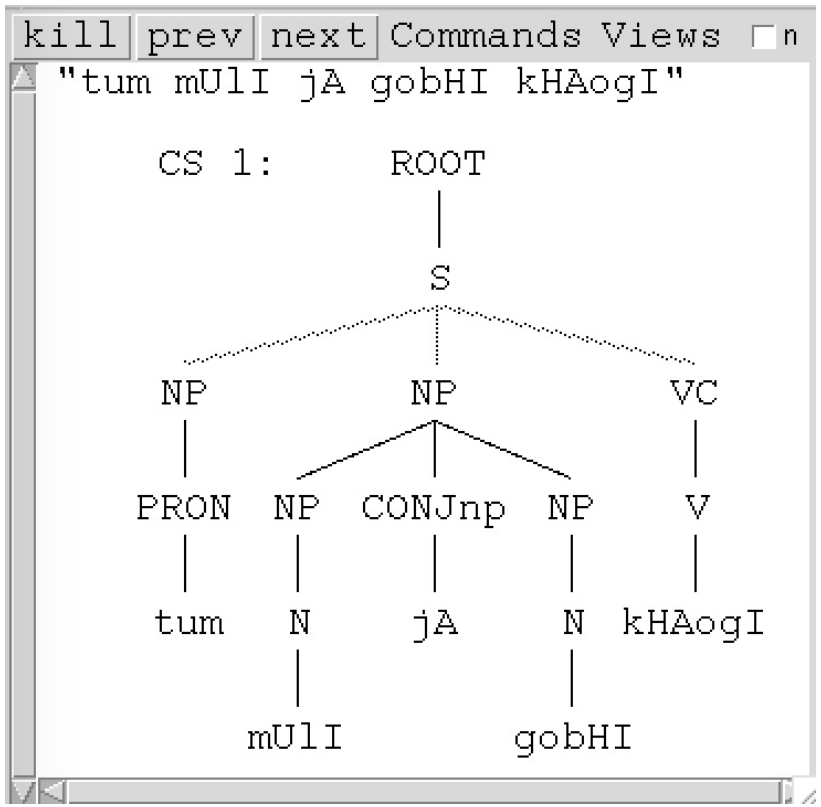


Figure: Single C-structure for the Three-way Ambiguous Sentence

Syntactic Analysis

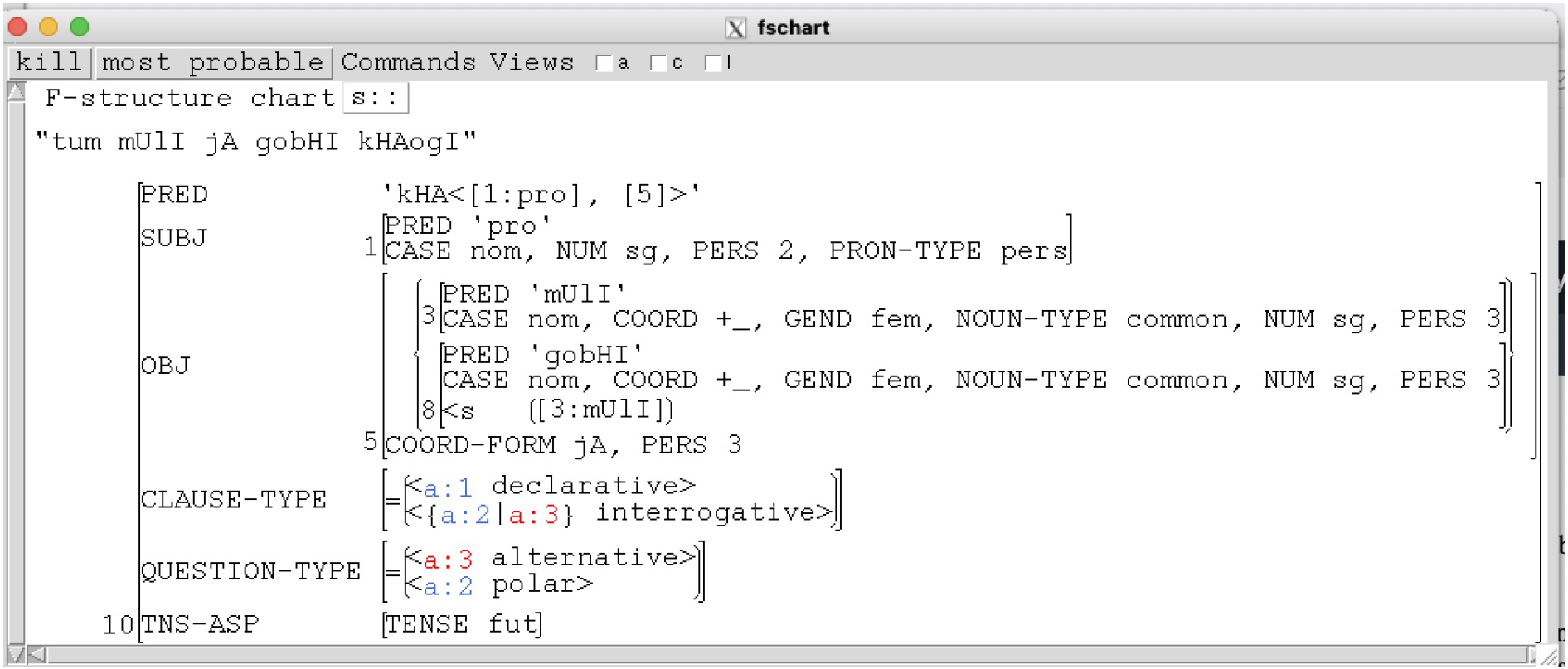


Figure: Packed F-structure for the Three-way Ambiguous Sentence

Syntactic Analysis

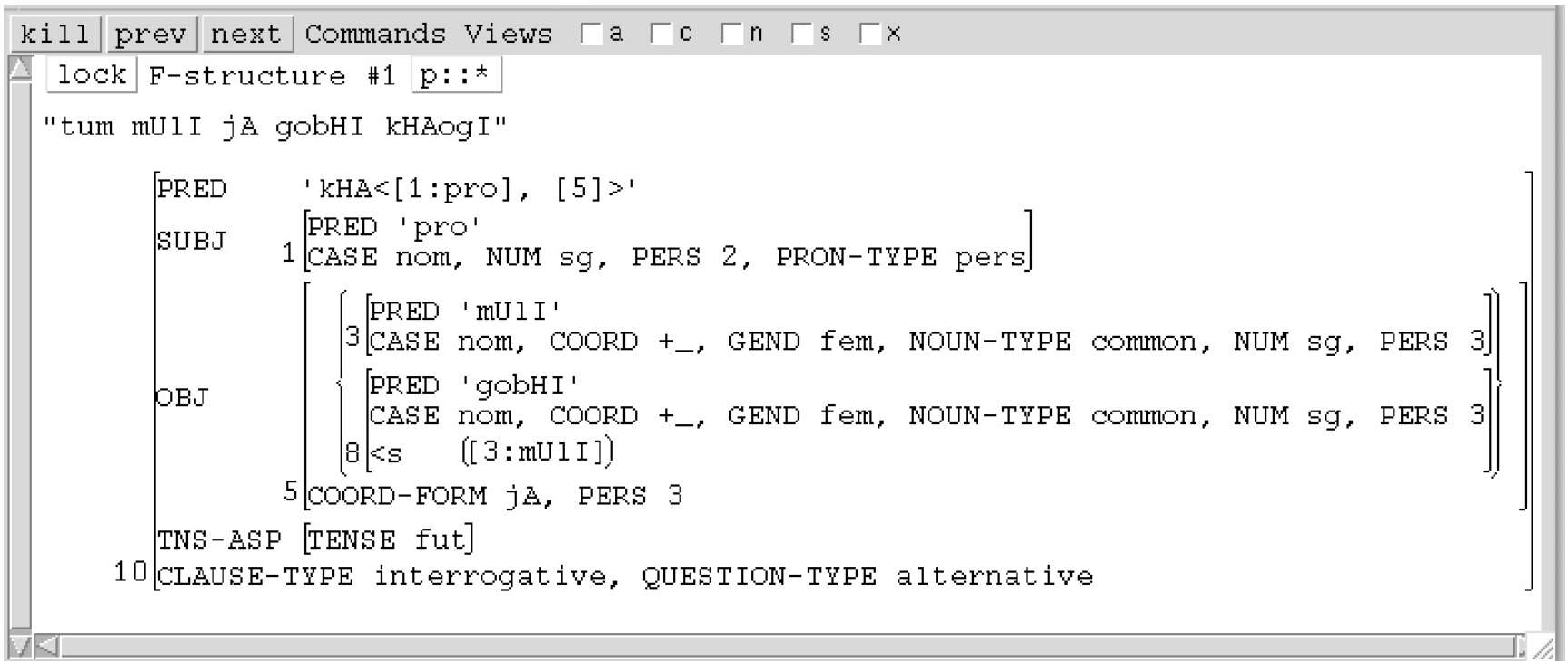


Figure: F-structure for Alternative Question Analysis

Syntactic Analysis

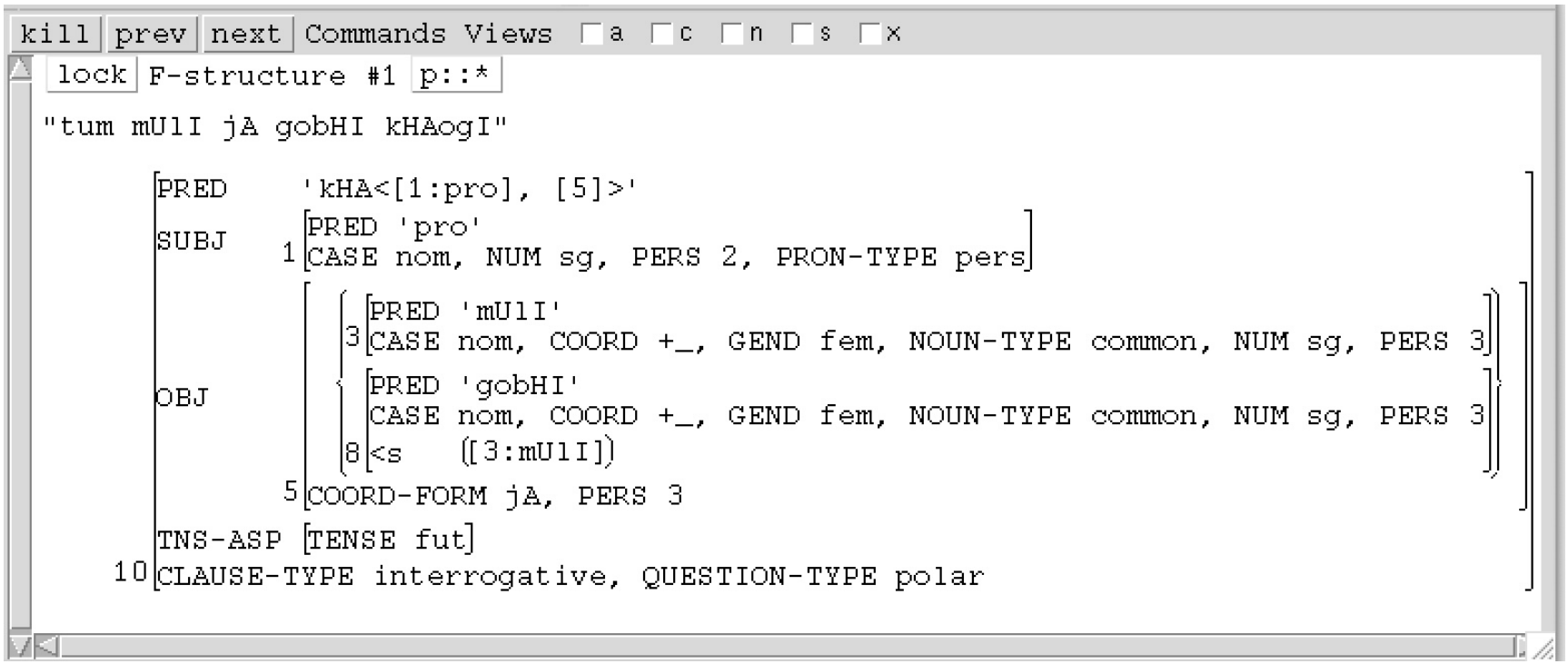


Figure: F-structure for Polar Question Analysis

Syntactic Analysis

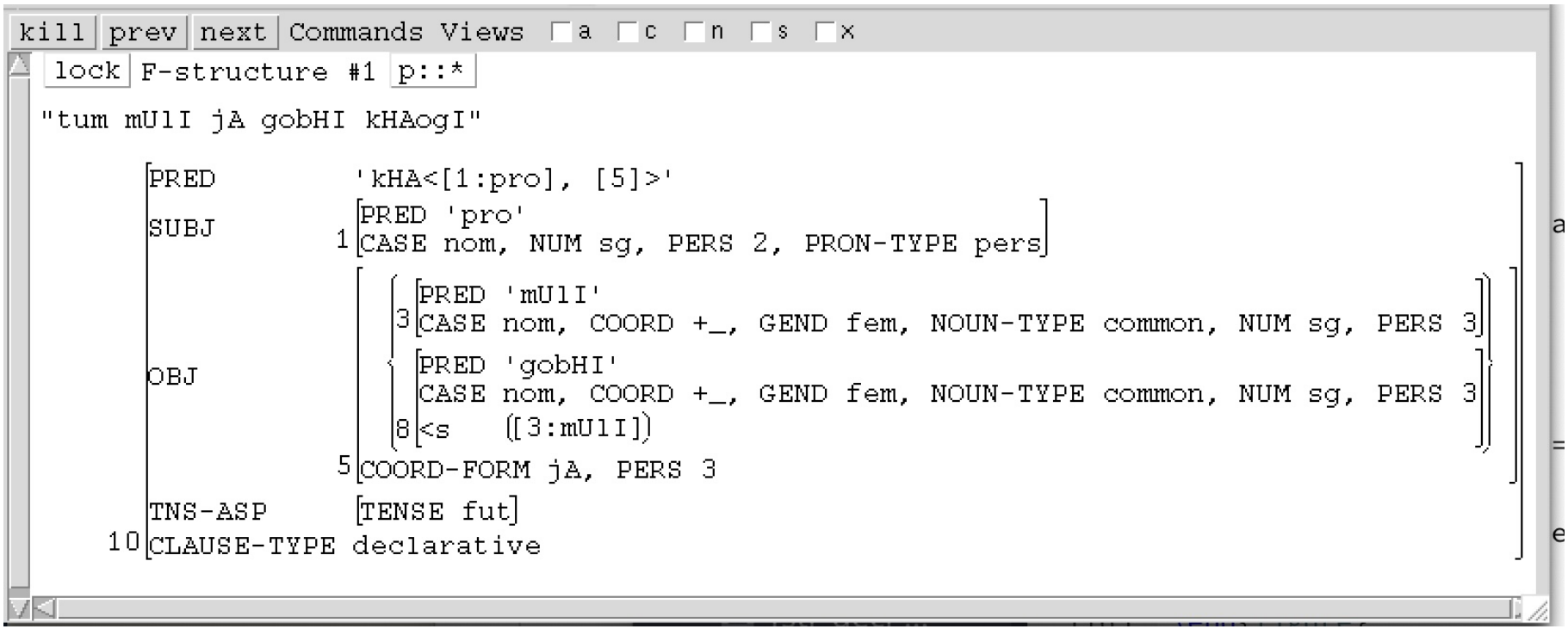


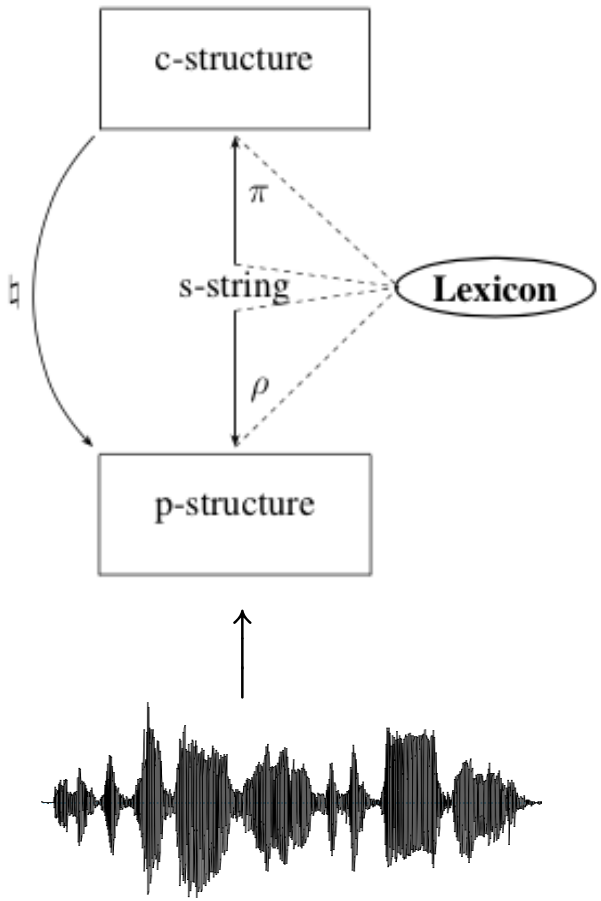
Figure: F-structure for Declarative Analysis

Structure of Talk

The prosody-syntax interface (Bögel 2015)

Exchange of information at the interface:

- The **transfer of vocabulary**: exchanges phonological and morphosyntactic information of lexical elements via the multidimensional lexicon
- The **transfer of structure** (ɸ): Information on syntactic and prosodic phrasing, and on intonation is exchanged
- During *comprehension*, information from the speech signal feeds into p-structure



The p-diagram

- p-structure is represented by the p-diagram
- During comprehension, the p-diagram encodes the speech signal over time
- Each syllable receives a vector which contains the values associated with that syllable

↑ PHRASING	...	$(\sigma$	$\sigma)_\omega$	$(\sigma)_\omega)_\iota$	...	↑ *interpretation*
TONES	...	–	–	L%	...	↓
...	...	...	...	...	...	
FUND. FREQ	...	142	151	128	...	*signal*
DURATION	...	0.25	0.32	0.43	...	↓
SEGMENTS	...	[ab]	[cde]	[fgh]	...	
VECTORINDEX	...	$\mathbf{S_n}$	$\mathbf{S_{n+1}}$	$\mathbf{S_{n+2}}$	...	

- On the *signal level*: information from the speech signal
- On the *interpretation level*: the interpretation of that information

Prosodic disambiguation

Recap: The three different constructions have distinct pitch differences

- alternative question: Play Sound
- polar question: Play Sound
- declarative: Play Sound

type	*coord-tone*	*boundary tone*		*clause-type*	*question-type*
alternative	H4	L%	→	interrogative	alternative
polar	H4	H%	→	interrogative	polar
declarative	H1/2	L%	→	declarative	–

H1 = small rise ... H4 = strong rise and strong fall; same pattern for L

The p-diagram for an alternative question

PROS.PHRASE	σ	(σ	σ	σ)	(σ	σ)	(σ	σ	σ)
TONES	–	–	L2	+H4	L2	+H4	–	–	L%
DURATION	0.123	0.212	0.143	0.138	0.194	0.133	0.190	0.079	0.173
FUND. FREQ.	320	266	247	419	240	301	204	194	191
SEGMENTS	[t̪ʊm]	[mu]	[li]	[jɑ]	[go]	[bʰi]	[kʰɑ]	[o]	[gi]
VECTORINDEX	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9

→ a strong H4 on the coordinator [jɑ] and a clear fall towards the end (L%)

The p-diagram for a polar question and a declarative

Polar question:

PROS.PHRASE	(σ	σ	σ)	(σ	σ)	(σ	σ	σ)
TONES	–	L2	+H4	L2	+H4	–	–	H%
DURATION	0.153	0.119	0.102	0.161	0.128	0.200	0.098	0.261
FUND. FREQ.	263	255	370	252	332	242	212	352
SEGMENTS	[mu]	[li]	[jɑ]	[go]	[b^hi]	[k^hɑ]	[o]	[gi]
VECTORINDEX	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9

A strong accent (H4) on [jɑ] and a strong rising final boundary tone (H%)

Declarative:

PROS.PHRASE	(σ	σ	σ)	(σ	σ)	(σ	σ	σ)
TONES	L1	–	H1	–	H1	–	–	L%
DURATION	0.225	0.118	0.142	0.148	0.108	0.250	0.140	0.164
FUND. FREQ.	228	217	231	196	200	178	162	152
SEGMENTS	[mu]	[li]	[jɑ]	[go]	[b^hi]	[k^hɑ]	[o]	[gi]
VECTORINDEX	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9

A weak accent (H1) on [jɑ] and a falling final boundary tone (L%)

Distinguishing alternative, polar, and declarative

type	*coord-tone*	*boundary tone*		*clause-type*	*question-type*
alternative	H4	L%	→	interrogative	alternative
polar	H4	H%	→	interrogative	polar
declarative	H1/2	L%	→	declarative	–

(9) Constraints associated with the conjunction [jɑ] 'or':

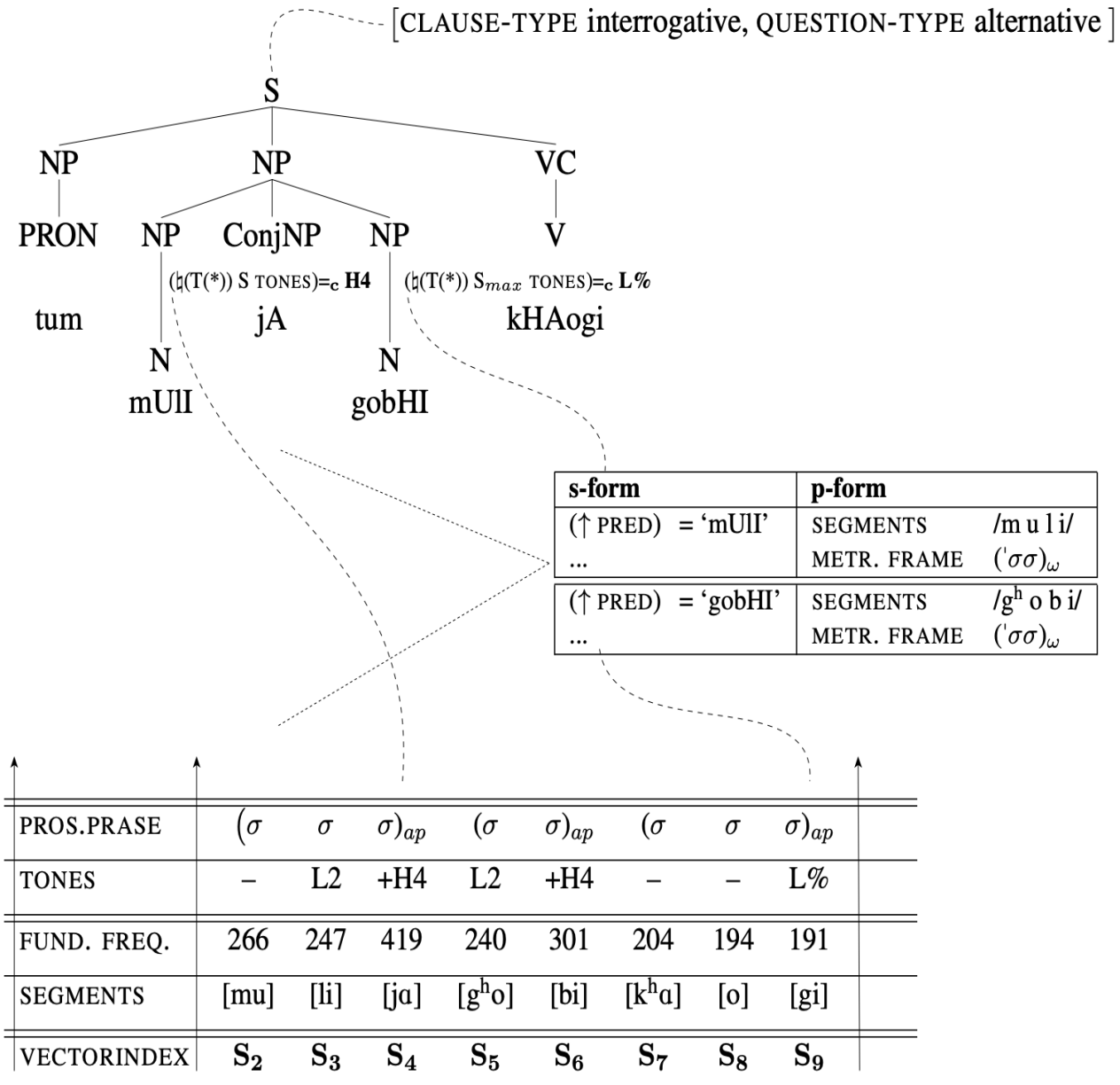
a. $(\natural(\mathrm{T}(*))\ \mathrm{S}\ \text{tones}) =_c \mathrm{H4}$
$(\uparrow \text{clause-type}) = \text{interrogative}$

b. $\{\ (\uparrow \text{question-type}) = \text{alternative} \mid (\uparrow \text{question-type}) = \text{polar}\ \}$

(10) Constraints associated with the clause final position:

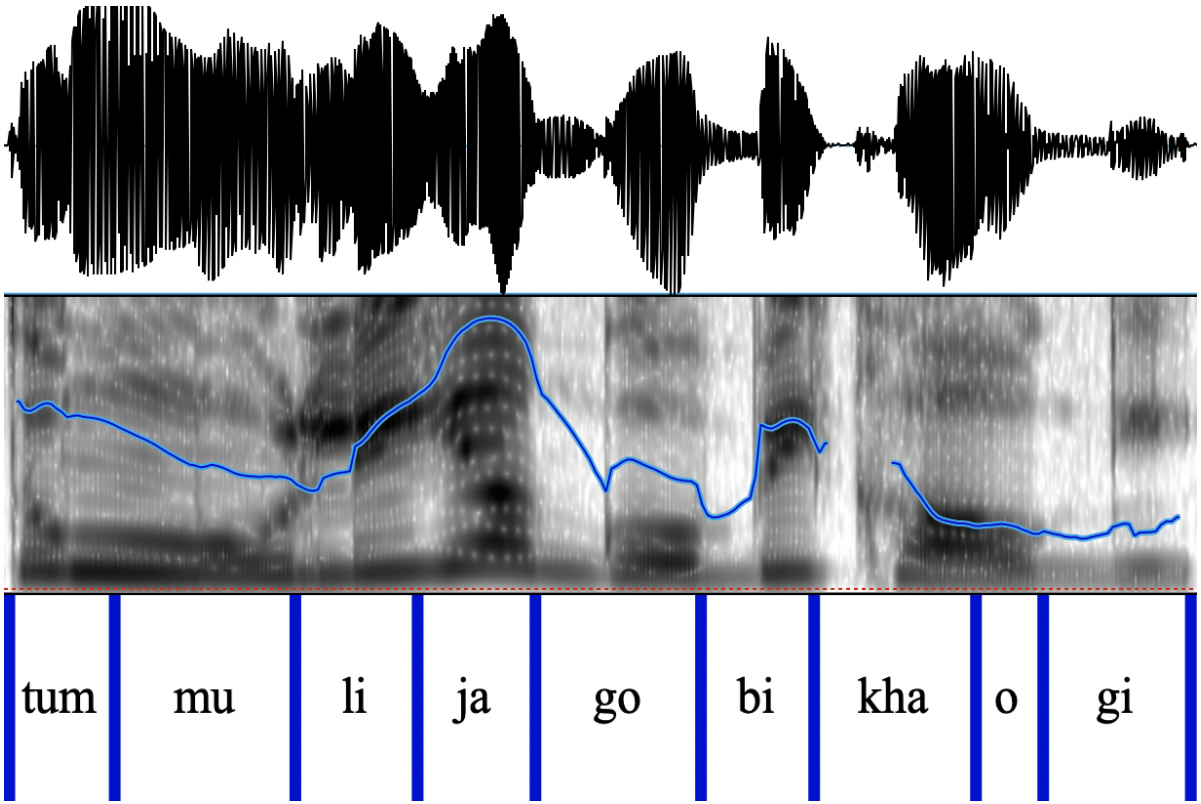
$$\{\quad (\natural(\mathrm{T}(*))\ \mathrm{S}_{max}\ \text{tones}) =_c \mathrm{L\%}$$
$$\{\quad (\uparrow \text{clause-type}) = \text{interrogative}$$
$$(\uparrow \text{question-type}) = \text{alternative}$$
$$\mid\quad (\uparrow \text{clause-type}) = \text{declarative}\quad \}$$
$$\mid\quad (\natural(\mathrm{T}(*))\ \mathrm{S}_{max}\ \text{tones}) =_c \mathrm{H\%}$$
$$(\uparrow \text{clause-type}) = \text{interrogative}$$
$$(\uparrow \text{question-type}) = \text{polar}\}$$

An alternative question during comprehension



This can also be implemented!

Input: A sound signal annotated with syllables:



- Implementation based on Bögel and Zhao (2024) for German and Bögel (2022).
- Here extended for the disambiguation of alternative, polar, and declarative structures.

Computational Implementation

1. Extracts all the information from the signal via Praat (the signal level).
   - divides the syllable into five even-spaced subintervals
   - → allows for a more fine-grained analysis of the pitch
   - → time-normalizes each syllable
   - all F0-values are turned into semitones
2. Interprets the signal information and assigns pitch accents, boundary tones, and prosodic constituents, based on:
   - → semitone differences (distance between two tones must be at least five intervals)
   - → duration (with reference to the duration of all syllables)
   - → residuals of a linear regression (which residuals are farthest away from the regression line)
3. Matches the input syllables against a lexicon (implemented in xfst; Beesley and Karttunen 2003) → *the transfer of vocabulary*

Input (p-string) | **Lexicon** | **Output (s-string)**

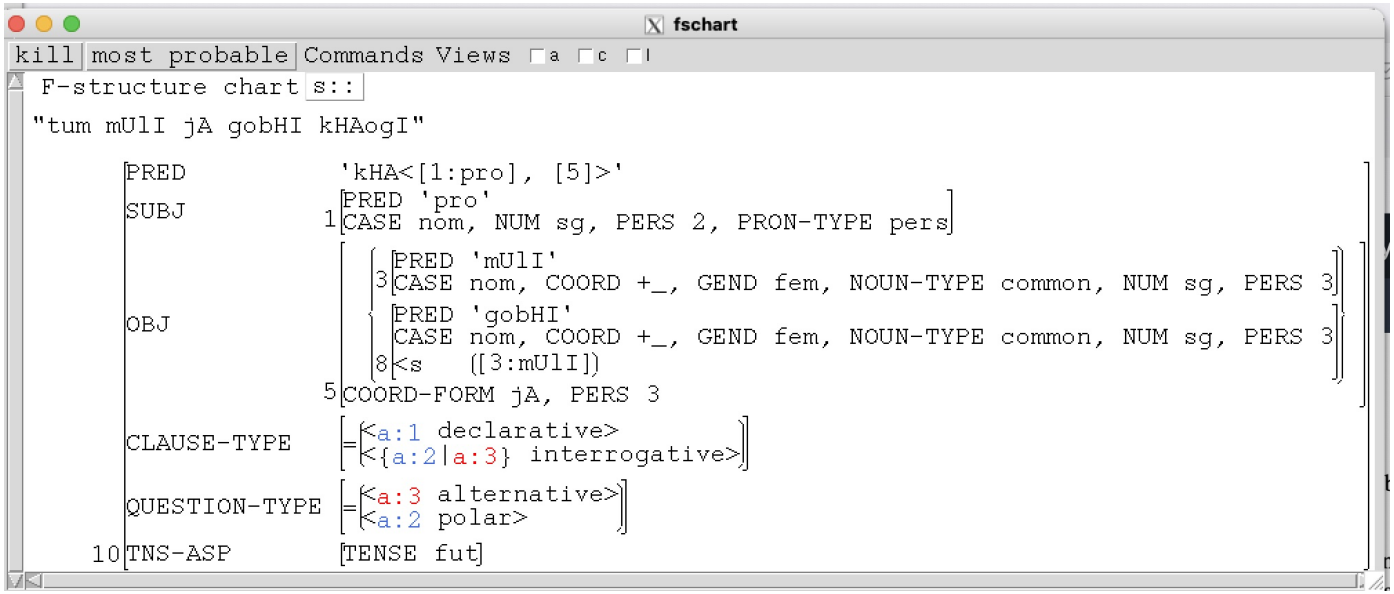
... mu.li.ja ... →

p-form	**s-form**
mu.li	mUlI
ja	jA
...	...

→ ... mUlI jA ...

Computational Implementation

4. Parses the resulting syntactic string with an XLE-grammar.



5. Identifies the ambiguous positions and checks back with p-structure → *the transfer of structure.*
6. Disambiguates the syntactic structures based on the findings!

And then we 'just' need the semantics on top of that :)

Structure of Talk

The semantics of questions

- Questions do not have a straightforwardly truth-conditional semantics.
- Following Hamblin (1976): questions denoted by the set of their (true) answers.

→ Questions represent alternatives for how the discourse may develop depending on the answer.

- We follow Biezma and Rawlins (2012) and Meertens (2021) in distinguishing alternative and polar questions
  - AltQ: set of possible answers
  - PolQ: singleton set.

Glue semantics

- Glue semantics is a strongly type-driven, resource-sensitive semantic formalism.
- Distinguishes between ...
  - the logic of composition (a fragment of linear logic, a resource-sensitive logic)
  - language of meaning (some meaning language embedded in lambda calculus, e.g., FOL+λ, λDRT)

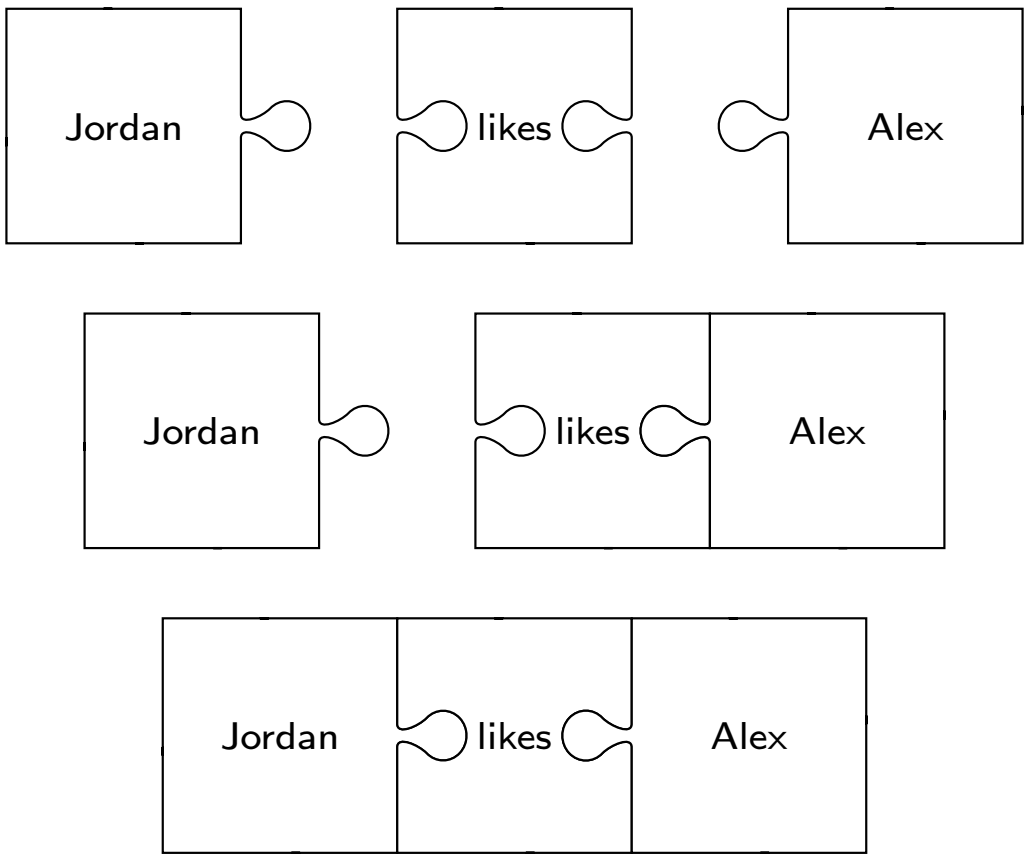
(11) A standard meaning constructor:
$g \multimap h \multimap f : \lambda x.\lambda y.like(x, y)$

- Linear logic resources can be associated with syntactic positions
- Different possibilities in different syntactic frameworks

(12) a. [Jordan$_g$ likes Alex$_h$]$_f$
b. $subj \multimap obj \multimap s$

Glue semantics II

- **Compositionality:** The meaning of a sentence is derived from the meanings of its parts
- **Resource-sensitivity:** Use only the meanings provided by the input and use each meaning only once



Glue semantics III – Formal representation

$$\frac{\begin{array}{c}[x : A]^i \\ \vdots \\ f(x) : B\end{array}}{\lambda x.f(x) : A \multimap B} \multimap_{I,i} \qquad \frac{f : A \multimap B \qquad a : A}{f(a) : B} \multimap_E$$

Figure: Implication introduction and elimination; CHI

(13)

Jordan	$g : \mathit{Jordan}$
Alex	$h : \mathit{Alex}$
like	$g \multimap h \multimap f : \lambda x.\lambda y.\mathit{like}(x, y)$

$$\frac{\dfrac{g : \mathit{Jordan} \qquad g \multimap h \multimap f : \lambda x.\lambda y.\mathit{like}(x, y)}{h \multimap f : \lambda y.\mathit{like}(\mathit{jordan}, y)} \qquad h : \mathit{Alex}}{f : \mathit{like}(\mathit{jordan}, \mathit{alex})}$$

Figure: Proof-tree for *Jordan likes Alex*

Glue semantics and alternatives

- Some pieces generate alternatives, e.g., the disjunction *or*
- pieces are multiplied but must be used together (still type driven)

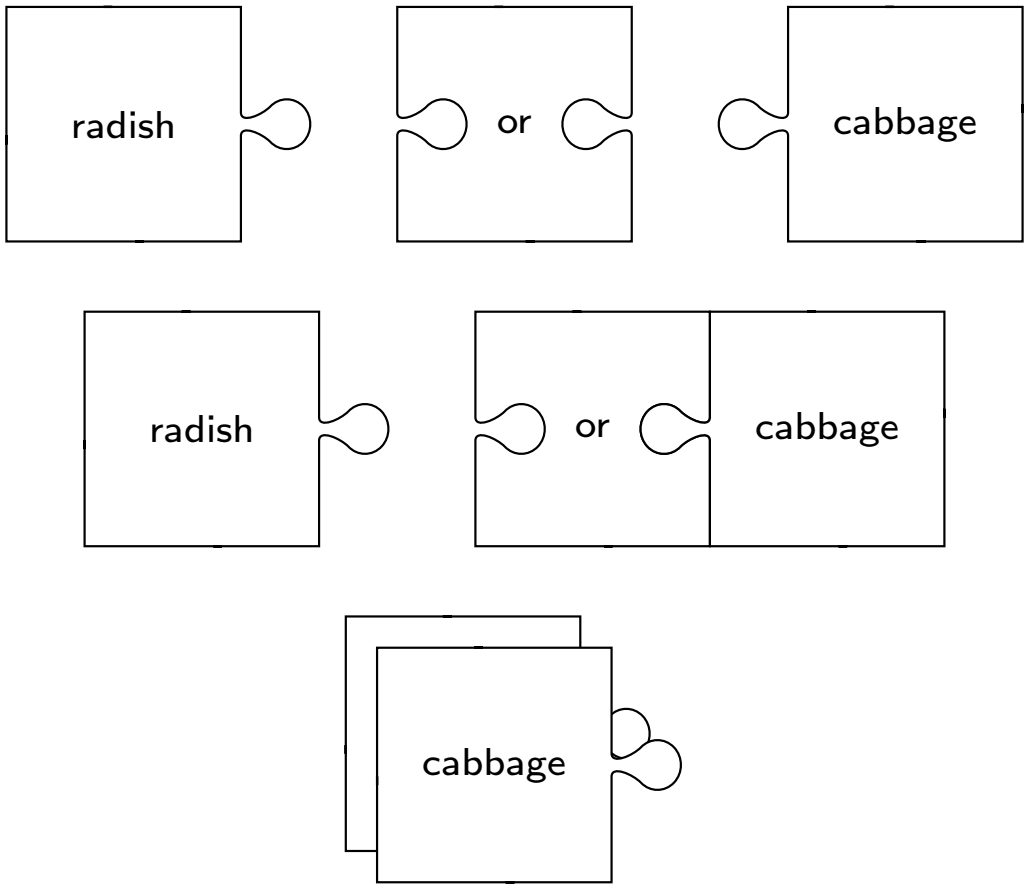


Figure: Creating alternatives

Glue semantics and alternatives

- Alternatives multiply pieces that they attach to propagating the set through a derivation

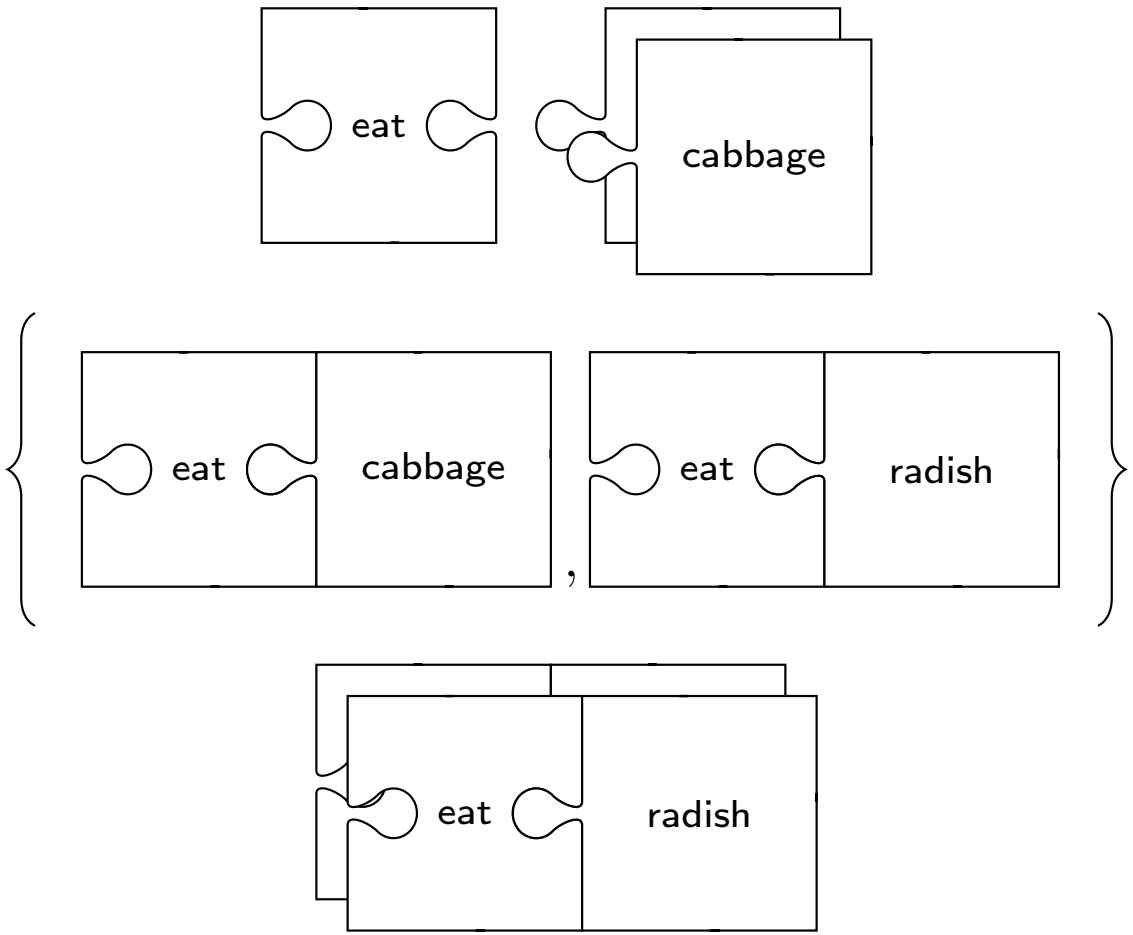


Figure: Alternative semantics

Function application with alternatives

- Combining alternatives is based on pointwise functional application (Kratzer and Shimoyama 2017)

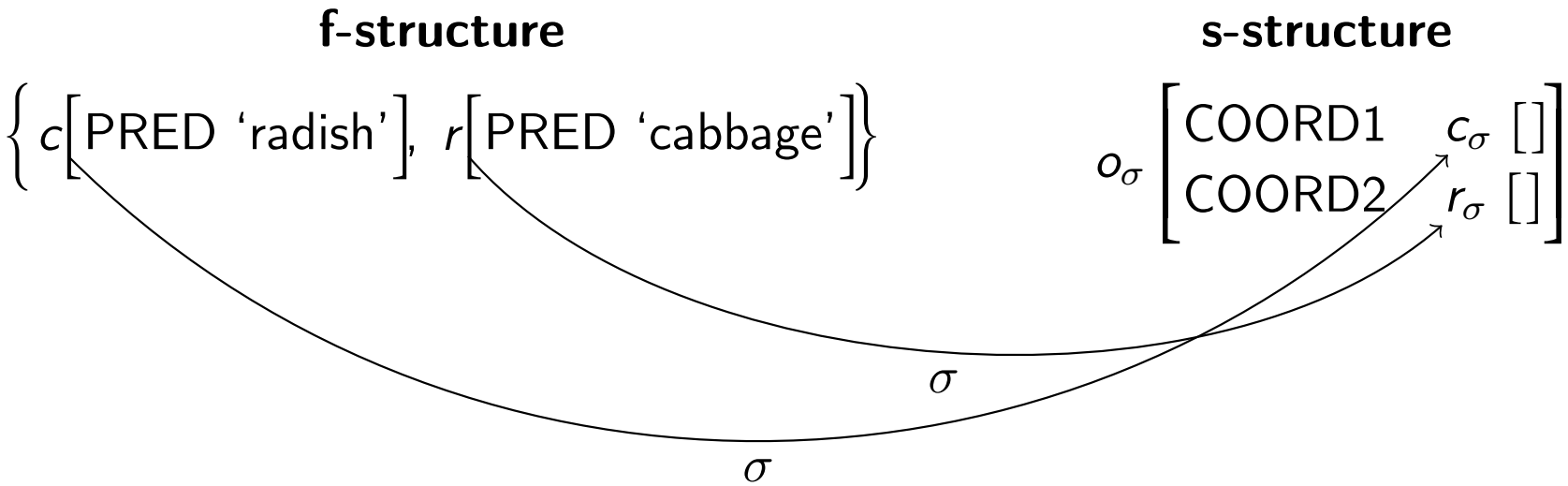
→ Forms the cartesian set of functors and arguments, where functors and arguments are reduced via implication elimination

$$\frac{\alpha : A \multimap_{\times} B \qquad \beta : A}{\{\alpha_i(\beta_j) \mid \alpha_i \in \alpha, \beta_j \in \beta\} : B} \multimap_{\times}\text{-E}$$

Figure: Implication elimination with alternatives

The syntax/semantics of the disjunction

(14) $\lambda x_e.\lambda y_e.x \cup y : r_\sigma \multimap c_\sigma \multimap o_\sigma$



- coordinated structures are treated as sets in LFG (order is captured in c-structure)
- the order (arguably) transmits to semantics

Glue semantics and alternatives formally

(15) a. Will you eat [radish or cabbage]$_o$?

Glue semantics and alternatives formally

(15) a. Will you eat [radish or cabbage]$_o$?

b.

or	$\lambda x.\lambda y.x \cup y : r_e \multimap c_e \multimap o_e$
cabbage	$cabbage : c_e$
radish	$radish : r_e$

Glue semantics and alternatives formally

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radish	$radish : r_e$

$$\dfrac{\dfrac{radish : r_e \qquad \lambda x.\lambda y.x \cup y : r_e \multimap c_e \multimap o_e}{\lambda y.\{radish\} \cup y : c_e \multimap o_e} \qquad cabbage : c_e}{\dfrac{\{radish\} \cup \{cabbage\} : o_e}{\{radish, cabbage\} : o_e}\ \cup}$$

Glue semantics and alternatives formally

(15) a. Will you eat [radish or cabbage]$_o$?

or	$\lambda x.\lambda y.x \cup y : r_e \multimap c_e \multimap o_e$
cabbage	$cabbage : c_e$
radish	$radish : r_e$
eat	$\lambda x.\lambda y.\lambda w.eat(x,y) : u_e \multimap o_e \multimap f_s \multimap f_t$
you	$you : u_e$

$$\dfrac{\dfrac{\dfrac{radish : r_e \quad \lambda x.\lambda y.x \cup y : r_e \multimap c_e \multimap o_e}{\lambda y.\{radish\} \cup y : c_e \multimap o_e} \quad cabbage : c_e}{\{radish\} \cup \{cabbage\} : o_e}\,\cup}{\{radish, cabbage\} : o_e} \quad \dfrac{\lambda x.\lambda y.\lambda w.eat(x,y,w) : u_e \multimap o_e \multimap f_s \multimap f_t \quad you : u_e}{\lambda y.\lambda w.eat(you,y,w) : o_e \multimap f_s \multimap f_t}$$

$$\dfrac{\{radish, cabbage\} : o_e \quad \lambda y.\lambda w.eat(you,y,w) : o_e \multimap f_s \multimap f_t}{\{\lambda w.eat(you, radish, w), \lambda w.eat(you, cabbage, w)\} : f_s \multimap f_t}\,\multimap_{\times}\text{-E}$$

Alternative Questions

(16) a. Will you eat [radish$_r$ or cabbage$_c$]$_o$?

b.

or	$\lambda x_e.\lambda y_e.x \cup y : r_e \multimap c_e \multimap o_e$
eat	$\lambda x_e.\lambda y_e.\lambda w_s.eat(x,y) : y_e \multimap o_e \multimap f_s \multimap f_t$
cabbage	$cabbage : c_e$
radish	$radish : r_e$
you	$you : y_e$
Q_{alt}	$\lambda p_{st}.Q(p) : (f_s \multimap f_t) \multimap f_{st}$

AltQ

$$\frac{\lambda p_{st}.Q(p) : (f_s \multimap f_t) \multimap f_{st} \qquad \{\lambda w_s.eat(you, radish, w), \lambda w_s.eat(you, cabbage, w)\} : f_s \multimap f_t}{Q\{\lambda w_s.eat(you, radish, w), \lambda w_s.eat(you, cabbage, w)\} : f_{st}}$$

Polar Questions

(17) a. Will you eat [radish$_r$ or cabbage$_c$]$_o$?

b.

or	$\lambda x_e.\lambda y_e.x \cup y : r_e \multimap c_e \multimap o_e$
eat	$\lambda x_e.\lambda y_e.\lambda w_s.eat(x,y) : y_e \multimap o_e \multimap f_s \multimap f_t$
cabbage	$cabbage : c_e$
radish	$radish : r_e$
you	$you : y_e$
Q_{pol}	$\lambda q_\alpha.\{\lambda w_s.\exists p[p \in q \wedge p(w) = 1]\} : (f_s \multimap f_t) \multimap f_{st}$

PolQ

$$\frac{\lambda q_\alpha.\{\lambda w_s.\exists p[p \in q : p(w) = 1]\} : (f_s \multimap f_t) \multimap f_{st} \qquad \{\lambda w_s.eat(you, radish, w), \lambda w_s.eat(you, cabbage, w)\} : f_s \multimap f_t}{\{\lambda w_s.\exists p[p \in \{\lambda w_s.eat(you, radish, w), \lambda w_s.eat(you, cabbage, w)\} : p(w) = 1]\} : f_{st}}$$

Alternatives – some assumptions

- All elements can be optionally treated as the singleton set containing themselves.
- We currently pursue a naive approach where once something becomes a set it cannot go back.
- For pure question semantics this seems to work well enough.
- Introducing different kinds of focus elements may complicate the picture (Rooth 1992; see also Beck and Kim 2006).
- We may need to take the optionality more strictly (think a lenticular print).
  - → Enriched meanings (Asudeh and Giorgolo 2020; future work).

Interim summary

- Alternatives are initially introduced by the disjunction *or*.
- Question semantics are introduced as a clausal operator at c-structure (but without an overt syntactic position)

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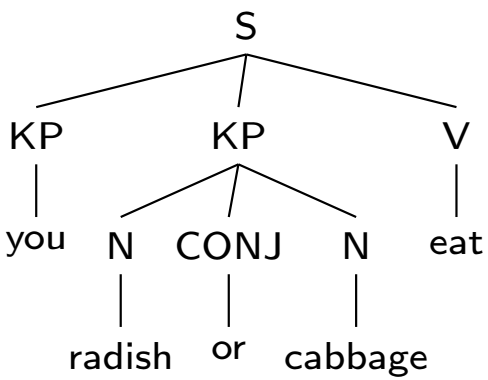

$\Rightarrow_{\phi \circ \sigma}$

$$\dfrac{\dfrac{\dfrac{\dfrac{radish : r_e \qquad x \cup y : r_e \multimap c_e \multimap o_e}{\{radish\} \cup y : c_e \multimap o_e} \qquad cabbage : c_e}{\{radish\} \cup \{cabbage\} : o_e}}{\{radish, cabbage\} : o_e} \cup \qquad \dfrac{eat(x, y, w) : u_e \multimap o_e \multimap f_s \multimap f_t \qquad you : u_e}{eat(you, y, w) : o_e \multimap f_s \multimap f_t}}{\{eat(you, radish, w),\ eat(you, cabbage, w)\} : f_s \multimap f_t} \multimap_{\times}\textbf{-E}$$

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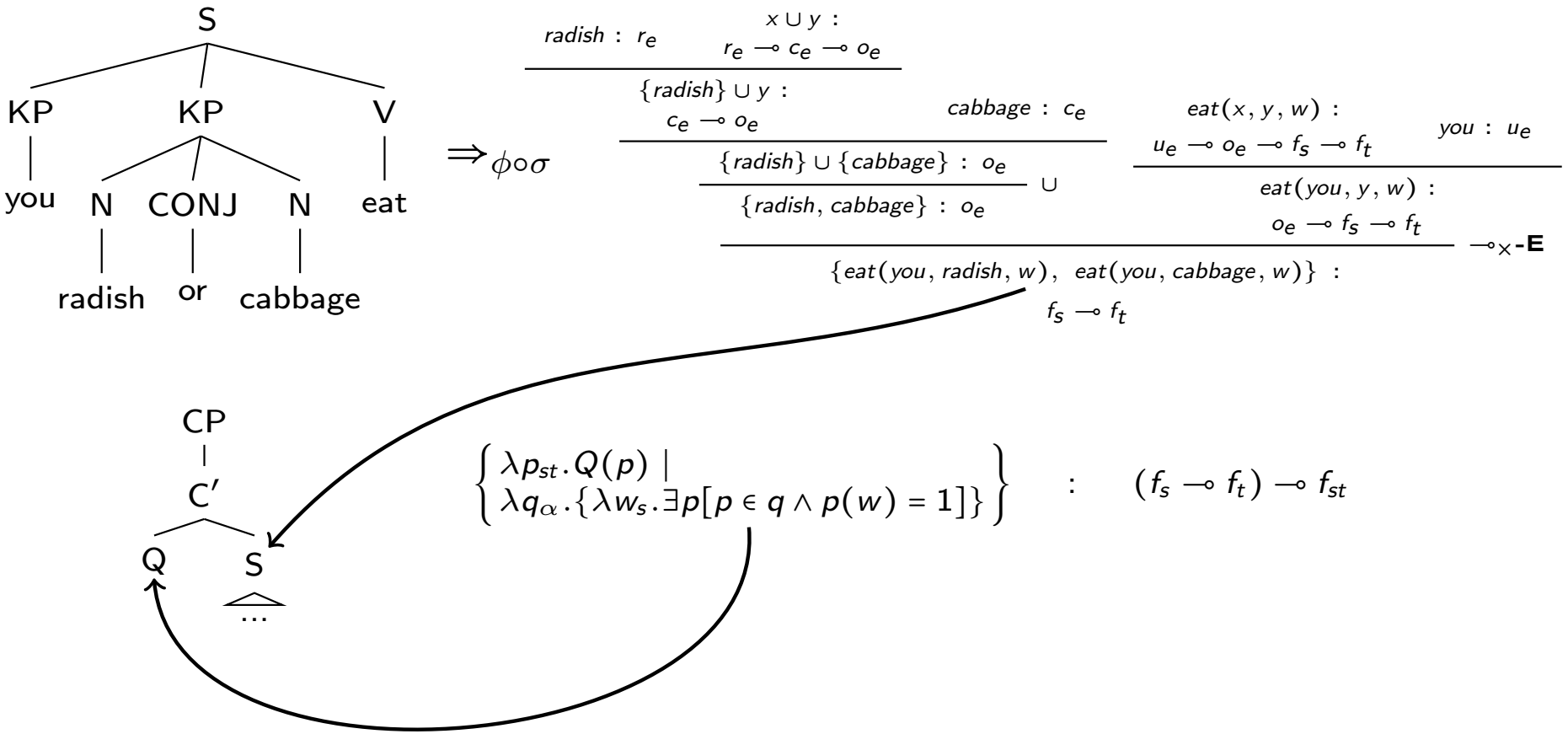

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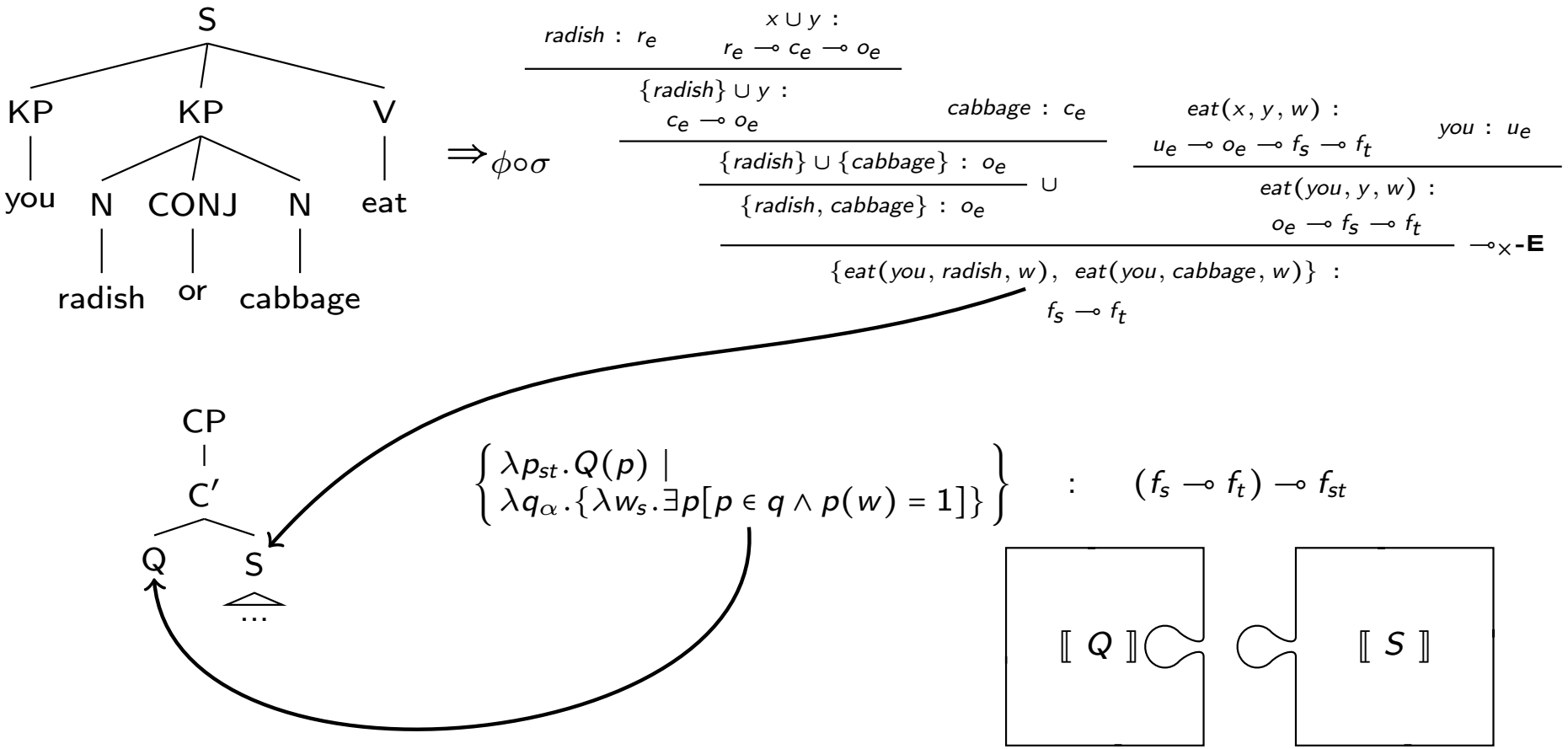

Implementation I – Syntax

- We take the basic ParGram approach to coordination.
- And add semantic information via the semantic (s::) projection (usually also known as σ-projection).

```
NPCOORD(_CAT) = "coordination of nominals"

        _CAT: @IN-SET "first nominal"
              @NP-CONJUNCT "calls person resolution template"
              (s::^ COORD1) = s::!;

        CONJnp: @PUSHUP; "conjunction"
        "PUSHUP avoids vacuous ambiguity in constructions like:
        COM{EX RULES NP: girls and boys}"

        _CAT: @IN-SET "second nominal"
              @NP-CONJUNCT
              (s::^ COORD2) = s::!
              :$ (/x_e.(/y_e.{x,y})) :
              ((s::^ COORD1)_e -o ((s::^ COORD2)_e -o s::^_e)).
          "Semantics may be dependent on a feature like COORD-FORM"
```

Implementation II – Syntax

- Question operators are encoded as semantic annotations of phrase structure
- f-structure features are used to transmit disambiguation from surface form to meaning (essentially optional)

```
ROOT --> S: ^=!
           {
              "declaratives and constituent questions"
              ...
           | (^ CLAUSE-TYPE)=interrogative
             (^ QUESTION-TYPE) = polar
             :$ (/q_a.{(/w_s.Ep_<s,t>(in(q,p) & eq(p(w),1)))}) :
             ((s::^_s -o s::^_t) -o s::^_t)
           |
             (^ @GF COORD-FORM) "only allow altq reading
                                 if have a coordination"
             (^ CLAUSE-TYPE)=interrogative
             (^ QUESTION-TYPE) = alternative
             :$ (/p_<s,t>.Q(p)) :
             ((s::^_s -o s::^_t) -o s::^_t)
           }.
```

Implementation III – Semantics

- Without diambiguation, the semantics produces two different readings for our running example (technicially three, including the declarative)

Meaning constructors:

```
cauliflower : 5_e
(/q_a.{(/w_s.Ep_<s,t>(in(p,q)&eq(p(w),1)))}) : ((12_s -o 12_t) -o 12_t)
[/x_e.[/y_e.[/w_s.eat(x,y,w)]]] : (10_e -o (3_e -o (12_s -o 12_t)))
you : 10_e
radish : 4_e
(/x_e.(/y_e.{x,y})) : (4_e -o (5_e -o 3_e))

cauliflower : 5_e
(/p_<s,t>.Q(p)) : ((12_s -o 12_t) -o 12_t)
[/x_e.[/y_e.[/w_s.eat(x,y,w)]]] : (10_e -o (3_e -o (12_s -o 12_t)))
you : 10_e
radish : 4_e
(/x_e.(/y_e.{x,y})) : (4_e -o (5_e -o 3_e))
```

Resulting solutions:

(18) $10 : \{\lambda w_s.\exists p[p \in \{\lambda z_s.\text{eat}(you, radish, z), \lambda z_s.\text{eat}(you, cauliflower, z)\} \wedge (p(w) = 1]\}$

(18) $20 : Q\{[\lambda w_s.\text{eat}(you, radish, w)], [\lambda w_s.\text{eat}(you, cauliflower, w)]\}$

Semantics: concluding remarks

- Implementing question semantics in LFG is fairly straightforward.
- Alternative semantics push the idea of resource sensitivity as they allow for simple copying of partial meanings.
- More complex examples, e.g., involving gapping, remain to be investigated.

  (19) Did Mary find Peter or Peter Mary?

  - May require deep distributivity (see Przepiórkowski and Patejuk 2023).
- The compositional system presented here is somewhat ad hoc but has good future perspectives by introducing monads that map to alternatives (Asudeh and Giorgolo 2020, see also Ciardelli and Roelofsen 2015).
- Some immediate future work:
  - → Extending the GSWB to deal with monads.
  - → look into inquisitive semantics.

Demo

Demo

live demonstration of the implementation

Summary

- We have presented an experiment on the prosody of alternative vs. polar questions in Urdu.
- The experiment identified several prosodic cues which disambiguate between alternative and polar questions.
- We presented a glue semantics analysis for alternative questions.
- And integrated this
  - with an LFG grammar
  - and a prosodic component
- To allow for a complete analysis:
  - speech signal as input
  - syntactic and semantic analysis as output

$\longrightarrow$ As far as we know LFG is the only formal framework that allows for a **holistic integration of prosodic information with morphosyntax and semantics**.

Acknowledgements

Thanks!

Very many thanks go to Rajesh Bhatt and Veneeta Dayal for the original inspiration and some further discussions, Saira Bano, María Biezma and Bettina Braun for help with the data, suggestions, general pointers and interesting discussions.

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Background on Prosody of AltQs

- Still very little work on Urdu/Hindi prosody (much of it now from Konstanz).
- Established crosslinguistic prosodic cues (Bartels 1999, Roelofsen and van Gool 2010, Biezma and Rawlins 2012):
  - For AltQs: a pitch accent on each disjunct and a final falling boundary tone.
  - For PolQs: no specific emphasis on the first disjunct and a final rising boundary tone.

(20) a. Did you cook PASta_↑ or RICE_↓ ?
'Which of the following things did you cook: pasta or rice?'
b. Did you cook pasta or RICE_↑ ?
'Is it true that you cooked pasta or rice?'

- To check for prosodic differences, in our experiment we measured the following acoustic properties:
  a. duration;
  b. pitch contour;
  c. lexical stress;
  d. phrasal breaks.

Results — For Details see Mumtaz and Butt (2024)

- **Duration:** longer durations for both NPs and the Conj in AltQs compared to PolQs, supporting that the NPs in the AltQs are in focus (cf. Patil et al. (2008), Genzel and Kügler (2010), Jabeen and Braun (2018)).

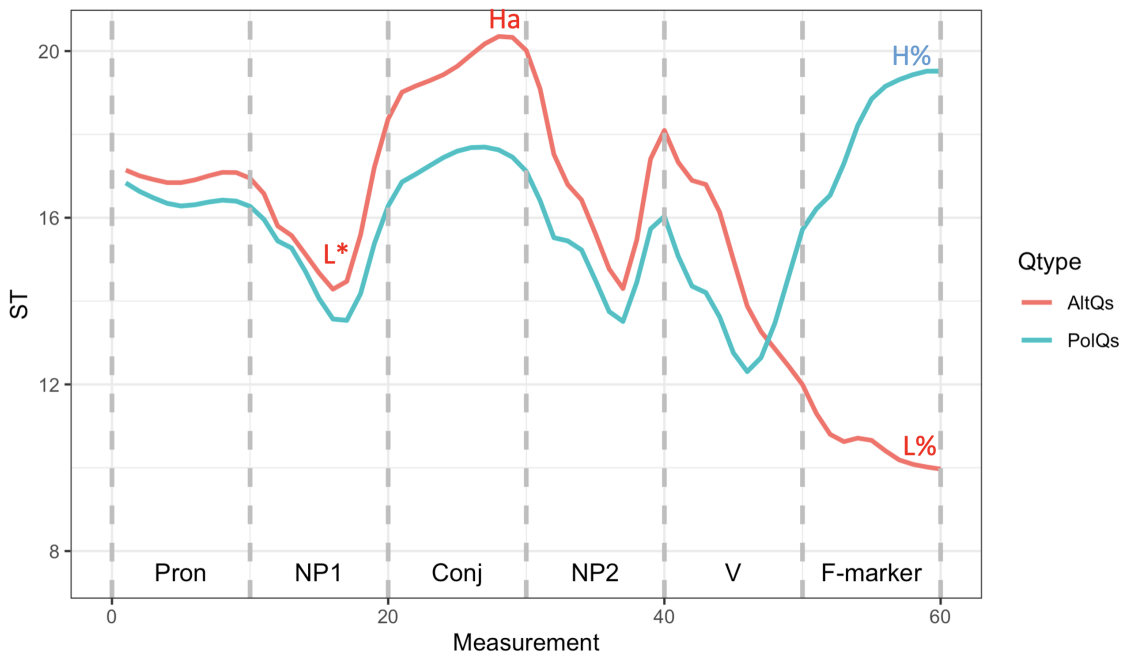

Figure: F0 Contour of string identical AltQs vs. PolQs