Parallellity, modularity, psychological reality: crucial notions at the interfaces

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This talk

- Grammar architecture
- In general: The relationship between modules
- In particular: The relationship between c-structure and p-structure
  1. Introduction to my approach to the syntax → prosody interface
  2. Comment on the prosody → syntax interface (German case ambiguities)
  3. Critical cases: Bulgarian pronominal clitics and linear order
- Underlying motivation for the approach: computationally implementable but also in line with psycholinguistic assumptions
- Two important notions here are ‘modularity’ and ‘parallelity’
Modularity

- Concept greatly influenced by research into the decomposition of the mind/the brain into faculties
- Fodor (1983) assumes that modules are
  - specialised, high-speed computational systems
  - process a given input and provide an output according to module-specific vocabulary and principles
  - each module is encapsulated/isolated
  - when the computation within one module is completed: information transferred to other modules or the ‘central system’
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    → information transferred to other modules or the ‘central system’
Does ‘language’ in itself also consists of modules? And if yes:

Are these modules

- isolated/encapsulated, contributing ‘in parallel’ to a language-internal ‘central system’, or
- are they rather positioned in a linear order between FORM and MEANING, feeding into each other?
Modularity and language

- Does ‘language’ in itself also consists of modules? And if yes:
- Are these modules
  - isolated/encapsulated, contributing ‘in parallel’ to a language-internal ‘central system’, or
  - are they rather positioned in a linear order between FORM and MEANING, feeding into each other?
- And how can these two approaches account for the two processing tasks that any act of language belongs to:
  1. production (from meaning to form - generation in computational terms)
  2. comprehension (from form to meaning - parsing in computational terms)
Modularity and language

→ This question is not openly discussed (or answered) in LFG ...
This question is not openly discussed (or answered) in LFG...

But the tension is implicitly present, where ‘parallely present’ structures are positioned in a particular order between ‘form and meaning’.

(Asudeh 2006)
Generative capacity assigned to three modules of the grammar: Syntax, Phonology, and Semantics → each with own primitives and principles
Jackendoff’s Parallel Architecture

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- Set of interface components link the respective structures — establishing a relation between FORM and MEANING
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- Set of interface components link the respective structures — establishing a relation between FORM and MEANING
- Jackendoff explicitly comments on this tension between ‘parallelity’ and ‘processing’:

  *PA is nondirectional, but its constraints can be implemented in any order suited to particular processing tasks.*

  (Jackendoff 2010, 589)
Jackendoff’s Parallel Architecture

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  \( \text{PA is nondirectional, but its constraints can be implemented in any order suited to particular processing tasks.} \)

  (Jackendoff 2010, 589)

- Proposes the following model of the PA in language production and comprehension:

```
Thought ←SEMANTICS← Lexicon ↓ Syntax ←PHONOLOGY← Hearing (comprehension)
```

(Speech (production))

(Jackendoff 2002, 197, modified)
Psycholinguistic insights

- Most assume existence of three levels: the conceptual/semantic, the syntactic, and the phonological (and phonetic) levels
Psycholinguistic insights

- Most assume existence of three levels: the conceptual/semantic, the syntactic, and the phonological (and phonetic) levels
- Are placed in a specific order depending on either comprehension or production
  - Linear order verified through numerous experimental evidence:
    - 1. research in speech errors
    - 2. studies with language-impaired subjects
    - 3. chronometric experiments
    - 4. event-related brain potentials (ERP)

\[
\text{production} \rightarrow \text{meaning} \rightarrow \text{semantics} \rightarrow \text{syntax} \rightarrow \text{phonology} \rightarrow \text{form} \leftarrow \text{comprehension}
\]
Psycholinguistic insights

- Most assume existence of three levels: the conceptual/semantic, the syntactic, and the phonological (and phonetic) levels.
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→ Linear order verified through numerous experimental evidence:
  1. research in speech errors
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  3. chronometric experiments
  4. event-related brain potentials (ERP)

production → meaning ... semantics → syntax → phonology ... form ← comprehension

Conclusion:
  1. modules process a particular part of linguistic information via structure-specific principles and constraints
  2. modules are aligned in a specific way between FORM and MEANING
→ Thus, reference to the particular act of language should be taken into account
And Parallelity?

‘Parallelity’ (in this context) means
- generative capacity, in that each component has its own principles and constraints that contribute to the analysis of a language phenomenon – exist ‘in parallel’
- also a reference to the overlapping of structures during incremental processing

‘Parallelity’ does not mean: encapsulated structures building up ‘in parallel’, to be aligned with the output of other components.

parallel approach: encapsulated modules

```
  syntax  ↓
    ↓
  string
  ↑
  phonology
```

linear approach: communicating modules

```
  syntax  ↓
    ↓
  phonology
    ↓
  string
```
The syntax–prosody interface

Creating a ‘map’ for production and comprehension:

- Two different modules, each with its own principles and vocabularies
- \( c \)-structure and \( p \)-structure
The syntax–prosody interface

Creating a ‘map’ for production and comprehension:

- Two different modules, each with its own principles and vocabularies
  → c-structure and p-structure
  → The **p-diagram**: a compact, syllable-based representation of p-structure

<table>
<thead>
<tr>
<th>PHRASING</th>
<th>(⋯⋯)ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>SEGMENTS</td>
<td>/am/  /ra/</td>
</tr>
<tr>
<td>V.-INDEX</td>
<td>S₁    S₂</td>
</tr>
</tbody>
</table>

1. abstract linear representation of speech over time,
2. lack of any morphosyntactic/semantic information
3. encodes prosodic phrasing, but does not rely on prosodic trees
4. compact, but can include all kinds of relevant information
5. p-structure includes a number of postlexical/postsyntactic phonological processes
The syntax–prosody interface

- Information exchanged between c- and p-structure needs to be ‘translated’
- In the approach presented here, information is exchanged on the basis of two transfer processes:

```
transfer of structure
```

```
transfer of vocabulary
```

---

*Transfer of structure*

*Transfer of vocabulary*
Transfer of vocabulary - the lexicon

- Operates only on the lexical level
- Requires extension of the lexical form
- Consider the following example (from Swabian):

  (1) I han en fragt wo e dr zucker fend
  I have him asked where I the sugar find
  ‘I asked him where I can find the sugar.’

<table>
<thead>
<tr>
<th>CONCEPT</th>
<th>S-FORM</th>
<th>P-FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>e</td>
<td>(↑ PRED) = ‘pro’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(↑ PRONTYPE) = pers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(↑ NUM) = sg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(↑ PERS) = 1</td>
</tr>
<tr>
<td>SUGAR</td>
<td>zucker</td>
<td>(↑ PRED) = ‘zucker’</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>(↑ NUM) = sg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(↑ GEN) = masc</td>
</tr>
</tbody>
</table>

| SEGMENTS   | /ə/    |
| MET. FRAME | =σ     |
| (↑ GEN)    | ('σσ)ω |
Transfer of vocabulary ($\rho$)

Transfer of metrical, segmental, and lexical prosodic information:

**c-structure**

... wo i dr zucker fend

**Lexicon**

<table>
<thead>
<tr>
<th>S-FORM</th>
<th>P-FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>SEGMENTS</td>
</tr>
<tr>
<td></td>
<td>/ə/</td>
</tr>
<tr>
<td>MET. FRAME</td>
<td>$=\sigma$</td>
</tr>
<tr>
<td>zucker</td>
<td>SEGMENTS</td>
</tr>
<tr>
<td></td>
<td>/ts u k e/</td>
</tr>
<tr>
<td>MET. FRAME</td>
<td>($'\sigma\sigma$)$_\omega$</td>
</tr>
</tbody>
</table>

**p-structure**

<table>
<thead>
<tr>
<th>PHRASING</th>
<th>...</th>
<th>$(\sigma)_\omega$</th>
<th>$=\sigma$</th>
<th>$=\sigma$</th>
<th>$(\sigma \sigma)_\omega$</th>
<th>$(\sigma)_\omega$</th>
</tr>
</thead>
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<tr>
<td></td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>LEX. STRESS</td>
<td>...</td>
<td>prim</td>
<td>-</td>
<td>-</td>
<td>prim</td>
<td>-</td>
</tr>
<tr>
<td>SEGMENTS</td>
<td>...</td>
<td>/vo:/</td>
<td>/ə/</td>
<td>/de/</td>
<td>/tsu/</td>
<td>/ke/</td>
</tr>
<tr>
<td>V.-INDEX</td>
<td>$S_1$</td>
<td>$S_2$</td>
<td>$S_3$</td>
<td>$S_4$</td>
<td>$S_5$</td>
<td>$S_6$</td>
</tr>
</tbody>
</table>
Transfer of structure (♮)

- Higher levels of syntactic structure translated into prosodic structure
- For example, via Selkirk (2011)'s *match theory*:

→ Every CP matches an Intonational Phrase (ι):

- $T(\ast)$ refers to all terminal nodes under the current node
- $\natural(f) \equiv \rho(\pi^{-1}(f))$
- where $S_{\text{max}}$ refers to the last syllable within the scope of CP
- where $S_{\text{min}}$ refers to the first syllable within the scope of CP

\[
\begin{align*}
\text{CP} & \quad \left(\natural(T(\ast))S_{\text{max}} \text{ PHRASING}\right) = \_\_ i \\
\left(\natural(T(\ast))S_{\text{min}} \text{ PHRASING}\right) & = \_ i
\end{align*}
\]
Transfer of structure (∈)

- Higher levels of syntactic structure translated into prosodic structure
- For example, via Selkirk (2011)'s *match theory*:
  - Every CP matches an Intonational Phrase (∈):
    - $T(\ast)$ refers to all terminal nodes under the current node
    - $\sharp(f) \equiv \rho(\pi^{-1}(f))$
    - where $S_{\text{max}}$ refers to the last syllable within the scope of CP
    - where $S_{\text{min}}$ refers to the first syllable within the scope of CP

\[
\begin{align*}
\text{CP} & \quad \sharp(T(\ast))S_{\text{max}} \quad \text{PHRASING} = \quad \iota \\
\text{(slope)} & \quad \sharp(T(\ast))S_{\text{min}} \quad \text{PHRASING} = \quad \iota
\end{align*}
\]

<table>
<thead>
<tr>
<th>PHRASING</th>
<th>\ldots</th>
<th>$\iota((\sigma)_{\omega}$</th>
<th>$=\sigma$</th>
<th>$=\sigma$</th>
<th>$(\sigma)_{\omega}$</th>
<th>$(\sigma)_{\omega}$</th>
<th>$\iota$</th>
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<tbody>
<tr>
<td>SEGMENTS</td>
<td>..</td>
<td>/vo:/</td>
<td>/ə/</td>
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<td>/tsu/</td>
<td>/ke/</td>
<td>/ɛnd/</td>
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<td>$S_6$</td>
<td>$S_7$</td>
</tr>
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Transfer of structure (ι)

- Higher levels of syntactic structure translated into prosodic structure
- For example, via Selkirk (2011)'s *match theory*:
  - Every CP matches an Intonational Phrase (ι):
  - \( T(\ast) \) refers to all terminal nodes under the current node
  - \( \ ♯(f) \equiv \rho(\pi^{-1}(f)) \)
  - where \( S_{\text{max}} \) refers to the *last* syllable within the scope of CP
  - where \( S_{\text{min}} \) refers to the *first* syllable within the scope of CP

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\begin{align*}
\text{CP} & \quad (\ ♯(T(\ast))S_{\text{max}} \ PHRASING) = \iota \\
& \quad (\ ♯(T(\ast))S_{\text{min}} \ PHRASING) = \iota \\
\end{align*}
\]

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<th>PHRASING</th>
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<th>( \iota \left( (\sigma)_{\omega} \right) = \sigma )</th>
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Mismatches between prosodic and syntactic structure are indicators that transfer of structure is not fully reversible.

Consider the German ambiguities:

\[ \text{(2)} \quad \text{Alle waren überrascht dass [der Partner] zuhört \(\text{CP}\)} \]
\[ \begin{aligned} \text{Everyone were surprised that [the partner] listened} \end{aligned} \]

\[ \begin{aligned} \text{DP}_1 \quad \text{the.ART.MASC.NOM partner} \\
\text{DP}_2 \quad \text{the.ART.FEM.GEN/DAT friend} \\
\text{zuhörte} \end{aligned} \]
Prosodic phrasing CAN disambiguate syntactic structuring in *comprehension* – but it often doesn’t!
Prosodic phrasing CAN disambiguate syntactic structuring in comprehension – but it often doesn’t!

Evidence from a production experiment with the German case ambiguities:

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<td>Dat</td>
<td>40</td>
</tr>
<tr>
<td>Duration</td>
<td>Dat</td>
<td>47</td>
</tr>
<tr>
<td>Reset</td>
<td>Dat</td>
<td>40</td>
</tr>
<tr>
<td>‘Flat’ first word</td>
<td>Gen</td>
<td>27</td>
</tr>
<tr>
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Reversibility

- Prosodic phrasing CAN disambiguate syntactic structuring in *comprehension* – but it often doesn’t!
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<td>20</td>
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- If the clause was unambiguous, e.g., with a masculine construction:
  
  *Der Partner des Freundes*

  → prosodic phrasing would not matter

  ⇒ The syntactic phrasing would ALWAYS be unambiguous!
Structure exchange during *comprehension*

It is for these reasons that the prosodic phrasing of p-structure is only **checked** and not automatically transferred during comprehension.

**Dative:**

<table>
<thead>
<tr>
<th>PHRASING</th>
<th>(\ldots \ldots \ldots \phi \ldots \ldots \ldots)</th>
<th>(\ldots \ldots \ldots \ldots \ldots \ldots )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEGMETS</td>
<td>([de^e]) ([pa^g]) ([tne]) ([de^e]) ([\ddnings]) ([d\ddnings])</td>
<td>(\ldots \ldots \ldots \ldots \ldots \ldots )</td>
</tr>
<tr>
<td>V.-INDEX</td>
<td>(S_1) (S_2) (S_3) (S_4) (S_5) (S_6)</td>
<td>(\ldots \ldots \ldots \ldots \ldots \ldots )</td>
</tr>
</tbody>
</table>

\[ \text{VP} \rightarrow \quad \text{DP} \quad \text{DP} \quad \text{V} \]

\[ \{ (\ddnings) S_{\text{max}} \text{ PHRASING}) =_{c} \phi \]

\[ \text{PHPBREAK} \in o^{*} \]

\[ |(\ddnings) S_{\text{max}} \text{ PHRASING}) \neq \phi \} \]

→ **Conclusion**: Direction matters!!
Intermediate Summary

Summing up: two transfer processes are assumed:


2. **transfer of structure**: c-structure phrasing is translated into prosodic phrasing. Not (or only to a specific extent) reversible \(\Rightarrow\) direction matters!

Non-reversibility seems to be restricted to prosodic phrasing only:

→ Postlexical phonological processes seem to be fully reversible

→ Even true if the phenomenon involves a considerable adjustment of syntactic linear order
Linear order alteration

- General assumption: c-structure encodes the hierarchical structure and linear order of the string
Linear order alteration

• General assumption: c-structure encodes the hierarchical structure and **linear order** of the string
• But: some phenomena are governed by p-structure constraints only
• Consider the following Bulgarian pronominal clitics:

(4) Petko \(=\text{mi}\) \(=\text{go}\) dade včera
    Petko me.dat it.acc gave yesterday
    ‘Petko gave it to me yesterday’

a) včera \(=\text{mi}\) \(=\text{go}\) dade Petko
b) včera Petko \(=\text{mi}\) \(=\text{go}\) dade
c) *Petko \(=\text{mi}\) \(=\text{go}\) včera dade
d) *\(=\text{mi}\) \(=\text{go}\) dade Petko včera
e) dade \(=\text{mi}\) \(=\text{go}\) Petko včera
Linear order alteration

- General assumption: c-structure encodes the hierarchical structure and linear order of the string
- But: some phenomena are governed by p-structure constraints only
- Consider the following Bulgarian pronominal clitics:

(5) Petko =mi =go dade včera
    Petko me.dat it.acc gave yesterday
    ‘Petko gave it to me yesterday’

a) včera =mi =go dade Petko
b) včera Petko =mi =go dade
c) *Petko =mi =go včera dade
d) *=mi =go dade Petko včera
e) dade =mi =go Petko včera

→ Bulgarian pronominal clitics are syntactically placed in front of the verb
⇒ If in initial intonational phrase position: **prosodically** replaced to follow the verb
Bulgarian clitics at the syntax–prosody interface

The syntax–prosody interface

Bulgarian clitics at the syntax–prosody interface

S

(η(T(∗)) S_{min}^{PHRASING}) = (η
(η(T(∗)) S_{max}^{PHRASING}) = )_{η}

VP

Pron Pron V

mi go dade

Lexicon

<table>
<thead>
<tr>
<th>S-FORM</th>
<th>P-FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>dade</td>
<td>SEGMETNS /d a d e/</td>
</tr>
<tr>
<td></td>
<td>MET. FRAME ('σσ)_{ω}</td>
</tr>
<tr>
<td>mi</td>
<td>SEGMETNS /m i/</td>
</tr>
<tr>
<td></td>
<td>MET. FRAME =σ</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th>PHRASING</th>
<th>SEGMENTS</th>
<th>V.-INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_{min}</td>
<td>l=σ</td>
<td>/mi/</td>
<td>S_{1}</td>
</tr>
<tr>
<td>S_{max}</td>
<td>=σ</td>
<td>/go/</td>
<td>S_{2}</td>
</tr>
<tr>
<td></td>
<td>(σ σ)_{ω}</td>
<td>/da/</td>
<td>S_{3}</td>
</tr>
<tr>
<td></td>
<td>(σ σ)_{ω}</td>
<td>/de/</td>
<td>S_{4}</td>
</tr>
<tr>
<td></td>
<td>(σ σ)_{ω}</td>
<td>/pet/</td>
<td>S_{5}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ko/</td>
<td>S_{6}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/včera/</td>
<td>S_{7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ra/</td>
<td>S_{8}</td>
</tr>
</tbody>
</table>
**Bulgarian clitics in p-structure**

### Production

<table>
<thead>
<tr>
<th>PHRASING</th>
<th>$i=\sigma$</th>
<th>$=\sigma$</th>
<th>$(\sigma \sigma)_w$</th>
<th>$(\sigma \sigma)_w$</th>
<th>$(\sigma \sigma)_w$</th>
<th>$i_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEGMENTS</td>
<td>/mi/</td>
<td>/go/</td>
<td>/da/</td>
<td>/de/</td>
<td>/pet/</td>
<td>/ko/</td>
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<td></td>
<td></td>
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<td>/vče/</td>
<td>/ra/</td>
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</tr>
<tr>
<td>V.-INDEX</td>
<td>$S_1$</td>
<td>$S_2$</td>
<td>$S_3$</td>
<td>$S_4$</td>
<td>$S_5$</td>
<td>$S_6$</td>
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<td>$S_7$</td>
<td>$S_8$</td>
<td></td>
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</tr>
</tbody>
</table>

### Postlexical Phonology

$$((i=\sigma)_w \omega_i \rightarrow (i \omega_i =(?^+)_w$$

<table>
<thead>
<tr>
<th>PHRASING</th>
<th>$i(\sigma \sigma)_w$</th>
<th>$=\sigma$</th>
<th>$=\sigma$</th>
<th>$(\sigma \sigma)_w$</th>
<th>$(\sigma \sigma)_w$</th>
<th>$i_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEGMENTS</td>
<td>/da/</td>
<td>/de/</td>
<td>/mi/</td>
<td>/go/</td>
<td>/pet/</td>
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<td>$S_2$</td>
<td>$S_3$</td>
<td>$S_4$</td>
<td>$S_5$</td>
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### Comprehension
Two views on p-structure

- **Strong** approach (prosodic inversion, insertion, etc...)
- **Weak** approach (an optimal candidate is elected via the application of a number of constraints):

  *Optimality theory*
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  → Drawback: a number of candidates have to be *created before filtering!"
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  1) *mi go* dade Petko včera
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→ Possible constraints to apply:
  - `ALIGN(R, CL, L, V)` and `NONINITIAL_INTP`
  - Ranking: `NONINITIAL_INTP ≫ ALIGN(R, CL, L, V)`
  - 2) would be the winner - ‘lower-ranked’ violation
Two views on p-structure – weak approach

However: candidate 2) is syntactically **not** motivated

→ unmotivated placement should then be allowed for all (syntactic) positions:

1) **mi go** dade Petko včera
2) dade **mi go** Petko včera
3) dade Petko **mi go** včera
4) dade Petko včera **mi go**
Two views on p-structure – weak approach

However: candidate 2) is syntactically not motivated
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1) mi go dade Petko včera
2) dade mi go Petko včera
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→ ... numbers candidates rising with every further token (constrained by syntax)
Two views on p-structure – weak approach

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1) *mi go dade Petko včera*
2) *dade mi go Petko včera*
3) *dade Petko *mi go* včera*
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→ ... numbers candidates rising with every further token (constrained by syntax)

⇒ Assuming the same procedures for postlexical phonology, the number of candidates quickly rises to Millions (see also Karttunen (1998))
Modularity and psycholinguistic assumptions about the arrangement of language-internal modules, and why a linear model is more feasible than a ‘match-up’-model
Conclusion

- Modularity and psycholinguistic assumptions about the arrangement of language-internal modules, and why a linear model is more feasible than a ‘match-up’-model
- Introduced a new approach to the syntax–prosody interface, which is modelled according to these assumptions and which provides a kind of underlying road map for production and comprehension processes
Conclusion

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- Introduced a new approach to the syntax–prosody interface, which is modelled according to these assumptions and which provides a kind of underlying road map for production and comprehension processes
- Different phenomena gave insights in a variety of interface aspects: German dative/genitive alternation showed that the relationship between syntactic and prosodic structuring is not necessarily reversible; Bulgarian clitics provided a case where the linear order suggested by c-structured is altered in prosody
Conclusion

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- And a more general comment on movement and filtering in postlexical phonology
Thank you!

... questions, comments...?
References

