Rethinking Linearisation

Joost Kremers
Goethe University, Frankfurt am Main

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Introduction

Linearisation

Goals of the talk

Standard Approaches

Problems

Linearisation

Phonology

Mapping

Conclusions

References
Linearisation

- Derivation of linear structure from hierarchical structure.
- Is this sufficient?
- Is it really the right way to look at it?
Goals of the talk

- To look a bit more closely at “linear” structure.
- To sketch a model of linearisation in terms of the mapping from syntax to phonology.
Standard Approaches
Implicit Assumptions

Standard approaches to linearisation in generative syntax make two fundamental assumption:

- **Totality**
- **Linear Correspondence**

(Cf. *Exclusivity Condition* and *Nontangling Condition*, Partee et al. 1993.)

Additionally, there is the belief that linear order is *all* that needs to be accounted for.
Totality

Every terminal node in the tree has a unique position in the linear sequence.

In the formulation of Kayne (1994):

(1) Given a tree $K$ and the set $T$ of terminals in $K$:
\[
\forall x, y \ (x, y \in T \land x \neq y) \ | \ x < y \lor y < x.
\]

where $x < y$ means ‘$x$ precedes $y$’.
If two elements are sisters in the tree, they are adjacent in the linear string.


(2) Linear Correspondence:
If a node X is structurally external to a node Y, then \( \Phi(X) \) is linearly external to \( \Phi(Y) \).

where \( \Phi \) is the linearisation function.
Problems

Problems

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Problems
Some data Questions
Semantic relations
Phonological relations
Structural relations
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Some data

Both assumptions are problematic:

(3)  with effort

STUDENT SIGN-LANGUAGE LEARN

‘The student learns SL with difficulty.’
(Leuninger 2005)

(4)  anxiously

CLOSET\textsubscript{a} CAT\textsubscript{b} WALK-ABOUT:Cl\textsubscript{b}:Loc\textsubscript{a}

‘A cat is walking about anxiously on the closet’
Some data

It is also possible for both hands to realise different signs simultaneously:

(5)  \(\text{hd:} \quad \text{not} \quad \text{NGT}\)
    \(\text{rh:} \quad \text{CUT}\)
    \(\text{lh:} \quad \text{NOW}\)

‘Don’t interrupt me now!’
(Miller 1994)

(6)  \(\text{rh:} \quad \text{BOY} \quad \text{BSL}\)
    \(\text{lh:} \quad \text{SMALL}\)

‘a small boy’
(Kyle and Woll 1985, 157)
Some data

What about question formation through intonation?

(7) \[ q \]
    \[ \text{tu sais danser?} \]
    you know dance
    ‘do you know how to dance?’

Or case marking through tone?

(8) a. \[ \text{é-dól } \varepsilon\text{mbártá} \]
    3-sees horse.ACC
    ‘the horse sees him’

b. \[ \text{é-dól } \varepsilon\text{mbartá} \]
    3-sees horse.NOM
    ‘he sees the horse’
There is more going on than just the lining up of terminal elements.

Sometimes elements are superimposed.

Questions:

- What types of elements can be superimposed?
- What is the relation between the two elements?
Questions

Elements that can be superimposed:

- Functional elements \((K^{\circ}, C^{\circ}[+wh], \text{also } Neg^{\circ})\)
- Adverbials
- Adjectives (at least persevered)
It seems that arguments can also be superimposed:

(9) \( \text{CLOSET}_a \quad \text{WALK-ABOUT:}\text{Cl}_{\text{animal}}:\text{Loc}_a \)

‘It is walking about anxiously on the closet’

(10) \( \text{m: push} \quad \text{h: BOAT} \)

‘push the boat’

(Sutton-Spence 2007)
Questions

What is the relation between the two superimposed elements?

<table>
<thead>
<tr>
<th>Complement</th>
<th>F^o</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>AdvP</td>
</tr>
<tr>
<td>Predicate</td>
<td>Argument</td>
</tr>
<tr>
<td>(Noun)</td>
<td>(Modifier)</td>
</tr>
</tbody>
</table>
Semantic relations

- Very little can be said about the semantic relation.
  - Pred-Arg
  - Verb-Adjunct
  - Negation-Clause
  - ...

- All that can be said is that there is *some* semantic relation.
At least one of the simultaneously realised elements must be segmental.

The other element(s) can be segmental or non-segmental.

That seems to be about all that can be said.
Green = segmental, red = non-segmental.
The elements realised simultaneously are structurally related, but not in a consistent way:

- Either may project.
- Either may be a head.

At best, we can say that both elements must be *sisters*. 
Totality

(1) Given a tree $K$ and the set $T$ of terminals in $K$:

\[ \forall x, y \ (x, y \in T \land x \neq y \mid x < y \lor y < x). \]

Totality is an inadequate descriptive generalisation. It is certainly not a guiding principle in linearisation.
Linear Correspondence

What about Linear Correspondence?

(2) Linear Correspondence:
If a node X is structurally external to a node Y, then $\Phi(X)$ is linearly external to $\Phi(Y)$.

This appears to be incorrect as well, since it is violated by every simultaneity example we have seen.

However, it may nonetheless play a role in linearisation.
Elements can be realised simultaneously. The requirements for simultaneity are:

- Two or more phonological chunks on different tiers.
- A sisterhood relation.

Yet, we know that items are (usually) linearly ordered.

- In principle, the linearisation procedure attempts to express the (non-ordered) sisterhood relation directly.
- If this is not possible, a linear ordering is chosen instead, obeying LC.
Linear order

- Linear order is a strategy of the phonological system.
- We will need some form of ordering parameters (head parameter).
- Crucially, such parameters are phonological in nature.
- That is, there can be no reference to linear order in syntax.
Derivation of phonological structure involves more than just linearisation.

- Phonological structure consists of a number of autonomous tiers (Goldsmith 1976).

- Syntactic elements are associated through mapping rules with phonological material (Jackendoff 2002, Ackema and Neeleman 2004):

\[
(11) \quad MAN_{\langle e,t \rangle} \leftrightarrow \begin{bmatrix} \text{N, sg count} \end{bmatrix} \leftrightarrow /mæn/
\]
The various phonological chunks that the mapping rules produce must be assembled into a phonological structure.

- Required principles:
  - Simultaneous realisation of sister nodes
  - If this fails: LC + ordering parameters
  - Left-to-Right Association (and language-specific exceptions)
An example: Sign language

■ Syntax:

■ Phonology:
An example: Sign language

**Syntax:**
- VP
  - AdvP
  - VP

**Phonology:**
An example: Sign language

Syntax:

```
VP

AdvP

facial: ANXIOUS

VP
```

Phonology:

```
``
An example: Sign language

- Syntax:

  AdvP

  VP

  facial: ANXIOUS

  manual: WALK-ABOUT

- Phonology:
An example: Sign language

- **Syntax:**
  - VP
    - AdvP
    - facial: ANXIOUS
    - manual: WALK-ABOUT

- **Phonology:**
  - facial:
  - manual:
An example: Sign language

■ Syntax:

```
Syntax:

AdvP  VP
facial: ANXIOUS  manual: WALK-ABOUT
```

■ Phonology:

```
Phonology:

manual:  WALK-ABOUT
```
An example: Sign language

- **Syntax:**
  - VP
    - AdvP
      - **facial:** ANXIOUS
    - VP
      - **manual:** WALK-ABOUT

- **Phonology:**
  - **facial:** ANXIOUS
  - **manual:** WALK-ABOUT
An example: Sign language

- Syntax:
  - VP
    - AdvP
    - facial: ANXIOUS
  - manual: WALK-ABOUT

- Phonology:
  - facial: ANXIOUS
  - manual: WALK-ABOUT
An example: Spoken language

- Syntax:

- Phonology:
An example: Spoken language

- Syntax:
  - VP
  - AdvP
  - VP

- Phonology:
An example: Spoken language

Syntax:

```
AdvP
```

```
VP
```

Phonology:

```
segm: /æŋkʃəslɪ/
```

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Linear Correspondence

Simultaneity

Phonological structure

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An example: Spoken language

■ Syntax:

```
AdvP
segm: /æŋkʃəslɪ/
```

```
VP

```

```
AdvP
segm: /wɔk əbəut/
```

■ Phonology:
An example: Spoken language

■ Syntax:

AdvP  
\[\text{segm:} /\æŋkʃəslɪ/\]

VP  
\[\text{segm:} /wɜːk æbəut/\]

■ Phonology: segmental:
An example: Spoken language

- Syntax:
  - AdvP
  - VP
  - $\text{segm: } /æŋkʃəsli/$
  - $\text{segm: } /wɔk əbaut/$

- Phonology: segmental: /wɔk əbaut/
An example: Spoken language

- Syntax:

  ![Syntax Diagram]

  - AdvP
  - VP

  `segm:` `/æŋkʃəsli/`

- Phonology:

  - `segmental:` `/æŋkʃəsli/`
  - `segm:` `/wɔːk ə'baut/`
An example: Spoken language

■ Syntax:

```
        VP
       /æŋkʃəsli/
 AdvP  segm: /æŋkʃəsli/  VP  segm: /wɔk əbaʊt/
```

■ Phonology:  segmental: /wɔk əbaʊt/  /æŋkʃəsli/
Phonological structure contains a hierarchy of *prosodic constituents*:

- Utterance (U)
- Intonational Phrase (IntP)
- Phonological Phrase (ϕ)
- Prosodic Word (ω)
- Foot (Ft)
- Syllable (σ)
- Mora (μ)

(cf. Nespor and Vogel 1986)
Prosodic hierarchy
In e.g. Arabic, prosodic structure is morphological (cf. McCarthy and Prince 1990):

<table>
<thead>
<tr>
<th>Perfective stem</th>
<th>Deverbal noun</th>
</tr>
</thead>
<tbody>
<tr>
<td>?aktab</td>
<td>?iktāb</td>
</tr>
<tr>
<td>inkatab</td>
<td>inkitāb</td>
</tr>
<tr>
<td>iktatab</td>
<td>iktitāb</td>
</tr>
<tr>
<td>iktabb</td>
<td>iktibāb</td>
</tr>
<tr>
<td>istaktab</td>
<td>istiktāb</td>
</tr>
<tr>
<td>iktātab</td>
<td>iktītāb</td>
</tr>
<tr>
<td>iktawtab</td>
<td>iktiwtāb</td>
</tr>
<tr>
<td>iktawwab</td>
<td>iktiwwāb</td>
</tr>
<tr>
<td>iktanbab</td>
<td>iktinbāb</td>
</tr>
<tr>
<td>iktanbay</td>
<td>iktinbāy</td>
</tr>
</tbody>
</table>
Prosodic morphology

Form: \( \text{'iktīb} \)

<table>
<thead>
<tr>
<th>root: /ktb/</th>
<th>nominaliser: /i a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem VIII: ( (\sigma)\sigma_\mu )</td>
<td>non-finite: ( \sigma_{\mu\mu} )</td>
</tr>
<tr>
<td>t</td>
<td></td>
</tr>
</tbody>
</table>

syllabic tier

segmental tier
Prosodic morphology

Form: \(^i\)ktit\(\bar{a}\)b

<table>
<thead>
<tr>
<th>root: /ktb/</th>
<th>nominaliser: /i a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem VIII: ((\sigma)(\sigma)(\mu))</td>
<td>non-finite: (\sigma)(\mu)(\mu)</td>
</tr>
</tbody>
</table>

\[ (\sigma) \quad \sigma \quad \mu \quad t \]

Syllabic tier

Segmental tier

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Form: \( ^1 \)ktit\( \bar{a} \)

<table>
<thead>
<tr>
<th>root: /ktb/</th>
<th>nominaliser: /i a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem VIII: ( (\sigma)\sigma_\mu )</td>
<td>non-finite: ( \sigma_{\mu\mu} )</td>
</tr>
<tr>
<td>( t )</td>
<td></td>
</tr>
</tbody>
</table>

\[
\begin{array}{ccc}
(\sigma) & \sigma & \sigma \\
\downarrow & \mu & \mu \\
t & \mu & \mu \\
\end{array}
\]

syllabic tier

segmental tier
Prosodic morphology

Form: ḳtītāb

<table>
<thead>
<tr>
<th>Root: /ktb/</th>
<th>Nominaliser: /i a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem VIII: (σ)σµ</td>
<td>Non-finite: σµµ</td>
</tr>
<tr>
<td>t</td>
<td></td>
</tr>
</tbody>
</table>

(σ) σ σ (σ) syllabic tier

(σ) µ σ µ µ segmental tier
Form: \(^i\)ktitāb

<table>
<thead>
<tr>
<th>root: /ktb/</th>
<th>nominaliser: /i a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem VIII: (σ)σμ</td>
<td>non-finite: σμμ</td>
</tr>
<tr>
<td>t</td>
<td></td>
</tr>
</tbody>
</table>

\[(σ) \quad σ \quad σ \quad (σ)\]

\[k \quad t \quad t \quad b\]

syllabic tier

segmental tier
Prosodic morphology

Form: \( ^i \)ktitāb

<table>
<thead>
<tr>
<th>root: ( /ktb/ )</th>
<th>nominaliser: ( /i,a/ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem VIII: ( (\sigma)\sigma_\mu )</td>
<td>non-finite: ( \sigma_\mu\mu )</td>
</tr>
<tr>
<td>t</td>
<td></td>
</tr>
</tbody>
</table>

\( (\sigma) \quad \sigma \quad (\sigma) \)

syllabic tier

\( k \quad t \quad i \quad t \quad a \quad b \)

segmental tier
Prosodic morphology

Form: \textit{i\textit{ktit\textbar{a}}}

\begin{center}
\begin{tabular}{|c|c|}
\hline
root: \textit{/ktb/} & nominaliser: \textit{/i a/} \\
stem VIII: (\sigma)\sigma_\mu & non-finite: \sigma_\mu_\mu \\
\hline
\end{tabular}
\end{center}

\begin{center}
(\sigma) \quad \sigma \quad (\sigma) \quad \text{syllabic tier}
\end{center}

\begin{center}
\begin{tabular}{cccc}
(\sigma) & \sigma & (\sigma) \\
\downarrow & \mu & \mu \\
k & t & t & a & b \\
\end{tabular}
\end{center}

\begin{center}
\mu \quad \mu \quad \mu \\
\end{center}

\begin{center}
\text{segmental tier}
\end{center}
The morphological structure of Arabic deverbal nouns can be described by means of a syntactic tree.

The linear order of the segments is determined by the *prosodic* structure.
The morphological structure of Arabic deverbal nouns can be described by means of a syntactic tree.

The linear order of the segments is determined by the *prosodic* structure.

*Proposal:* Prosodic structure is relevant for the linearisation of *syntactic* structures as well.
For example:


(12) **WRAP-X**: A syntactic head must be wrapped in a prosodic word.

\[
\text{CAR} \leftrightarrow \left[ N, \text{sg count} \right] \leftrightarrow /\text{kar}t/\omega
\]
Prosodic linearisation

U

IntP

φ

ω

σ

IntP

φ

ω

σ

Ordering I

Ordering II

Ordering III

Head parameter
Prosodic linearisation

(13) \textbf{WRAP-XP:} a syntactic phrase must be wrapped in a phonological phrase.

\[ \forall x (\text{car}(x) \land \text{blue}(x)) \leftrightarrow \text{NP} \leftrightarrow \{/\text{ðəbluː} \text{kaɪ}/\} \]
Prosodic linearisation

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Ordering I: Specifiers

- Specifiers are XPs and are therefore subject to WRAP-XP.
- The sister of a specifier is an intermediate projection and is irrelevant to phonology.
- Suggestion: For this reason, specifiers tend to be linearised to the left: the phonological system deals with them first, and only deals with the head and complement in a subsequent step.
As Truckenbrodt (1995) shows, the two-segment XP in an adjunction structure is prosodically irrelevant.

Adjuncts are maximal projections and therefore subject to \textit{WRAP-XP}.

The sister of an adjunct is also a maximal projection subject to \textit{WRAP-XP}.

Because of this reason, there is order variation among adjuncts: Adv-V vs. V-Adv, Adj-N vs. N-Adj, etc.
Complements are XPs and are therefore subject to $\text{WRAP-XP}$.

The sister of a complement is a head and therefore subject to $\text{WRAP-X}$.

As with adjuncts, the fact that both sisters are subject to mapping rules means ordering variation exists.
Stress Alignment:

- **STRESS-XP**: Every syntactic phrase has $\varphi$-stress.

- There is a correlation between the alignment of stress and the directionality of head-complement structures:
  - head-initial $\leftrightarrow$ $\varphi$-final stress ("read the book")
  - head-final $\leftrightarrow$ $\varphi$-initial stress ("das Buch lesen")
Truckenbrodt (1995) proposes a *phonological* rule that aligns the right/left edge of a $\varphi$ with stress:
For Truckenbrodt, linearisation is syntactic, so that before application of \( \text{ALIGN} \text{R/L-} \varphi \varphi \times \varphi \), the relevant structure is already linearised:

\[
\begin{array}{c}
\text{VP} \\
\downarrow \\
\text{read} \quad \text{NP} \\
\downarrow \\
\text{the} \quad \text{book}
\end{array}
\]

| /\text{ri}:d \ ə'buk/ \varphi | \checkmark \text{VP} & \checkmark \text{NP} | \checkmark \text{VP} & \checkmark \text{NP} \\
| /'\text{ri}:d \ ə'buk/ \varphi | \checkmark \text{VP} & \checkmark \text{NP} | \checkmark \text{VP} & \checkmark \text{NP} & \text{*NP} |
For Truckenbrodt, linearisation is a given. But do we really need to assume this?

<table>
<thead>
<tr>
<th></th>
<th>WRAP-XP</th>
<th>STRESS-XP</th>
<th>ALIGNR-ϕ, ×ϕ</th>
</tr>
</thead>
<tbody>
<tr>
<td>/riːd dəˈbuk/</td>
<td>✓VP</td>
<td>✓NP</td>
<td>✓VP ✓NP</td>
</tr>
<tr>
<td>/ˈriːd dəˈbuk/</td>
<td>✓VP</td>
<td>✓NP</td>
<td>✓VP *NP</td>
</tr>
<tr>
<td>dəˈbuk riːd/</td>
<td>✓VP</td>
<td>✓NP</td>
<td>✓VP ✓NP</td>
</tr>
<tr>
<td>dəˈbuk 'riːd/</td>
<td>✓VP</td>
<td>✓NP</td>
<td>✓VP *NP</td>
</tr>
</tbody>
</table>
Mapping

From syntax to phonology
Stress and Alignment
Wrapping
Conflicting rules

Conclusions

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From syntax to phonology

- **WRAP-X, WRAP-XP, STRESSXP and ALIGNR/L** are all constraints from OT-style analyses.

- A reformulation as mapping rules is not always straightforward.
Stress and Alignment

- **STRESSXP** is rather simple:
  
  \[
  \times \\
  | \\
  \text{XP} \leftrightarrow \varphi
  \]

- **ALIGNR/L-\varphi,\times** is a purely phonological requirement without syntactic (or semantic) associate:
  
  \[
  \times \\
  | \\
  \text{ALIGNL-}\varphi,\times: \{\omega^*\} \quad \text{ALIGNR-}\varphi,\times: \{^*\omega\}
  \]
The only way to represent $\text{WRAP-X}$ and $\text{WRAP-XP}$ is as follows:

\[(14) \quad \begin{align*}
\text{a. } & \text{WRAP-X: } X \leftrightarrow \omega \\
\text{b. } & \text{WRAP-XP: } XP \leftrightarrow \varphi
\end{align*}\]

This, however, is not exactly equivalent to Truckenbrodt’s $\text{WRAP-XP}$:

\[(15) \quad \left[ \text{VP read } \left[ \text{NP the book } \right] \right] \leftrightarrow /riːd ðə'bʊk/ \varphi\]

(15) satisfies the original $\text{WRAP-XP}$ for the NP, but it does not satisfy the reformulation in (14b).
In the linearisation of [read [the book]], several rules apply:

(16) **Lexical Rules:**
   a. \( V \leftrightarrow \text{ri:d} \omega \)
   b. \( N \leftrightarrow \text{buk} \omega \)
   c. \( D \leftrightarrow \text{də } \sigma \)

(17) **Wrapping and Stress:**
   a. \( V,N \leftrightarrow \omega \)
   b. \( \text{VP,NP} \leftrightarrow \varphi \)

(18) **Alignment:**
   \( \times \)
   \( \{ * \omega \} \varphi \)
Conflicting rules

- All rules apply simultaneously.
- Obviously, a conflict arises: if VP corresponds to a $\varphi$, NP cannot do so at the same time.
- We need some form of conflict resolution.
Conflicting rules
Conflicting rules

(19) $\varphi$

$\omega$ $\omega$
Conflicting rules
Conflicting rules

(19)

\[
\omega \quad \varphi \quad \omega
\]

\text{riːd} \quad \text{ðəbuk}
Conflicting rules

(19)

(20)

\( \varphi \)

\( \omega \)

\( \omega \)

riːd
dəɛbuk

riːd
dəɛbuk
In (19), VP $\leftrightarrow \varphi$ applies, while while in (20), NP $\leftrightarrow \varphi$ applies.

In (19), the Alignment rule in (18) also applies, which strengthens the application of VP $\leftrightarrow \varphi$.

In (20), Alignment does not apply, i.e., the structure is essentially not linearisable.
Conflicting rules

Proposal:

- Specific (applications of) rules can strengthen or inhibit each other.

- Alignment in (18) strengthens VP $\leftrightarrow \phi$, so that (19) wins out.
Rules exist as mapping rules, connecting chunks of semantic, syntactic, and phonological structure.

A rule need not link chunks of structure in all three modules. It may link just two, or even just one.

Any principle that cannot be expressed as a piece of structure cannot be expressed as a mapping rule.

E.g., no mapping rule can state that something is not allowed.
Linearisation is not a simple matter of lining up the terminal elements.

In essence, the phonological component attempts to retain the unorderedness (simultaneity) of sisterhood.

When this fails (which is most of the time) an alternative strategy is used: linearisation.

Linearisation is therefore a purely phonological phenomenon.
Conclusions

- The direction of linearisation must therefore also be determined purely phonologically, or in the mapping from syntax to phonology.

- Mapping rules link chunks of structure.

- On the phonological side, all chunks must be incorporated into a licit structure.

- Rules may strengthen or inhibit each other.


H. Leuninger. Sign languages: Representation, processing, and interface conditions. ms. University of Frankfurt, 2005

References


