Inflectional Morphology as Syntax

Cem Bozşahin

Computer Eng. & Cognitive Science
Middle East Technical University (METU), Ankara

(currently visiting)

Institute for Communicating & Collaborative Systems
Division of Informatics, University of Edinburgh
Overview

- Examples of bracketing mismatches and phrasal scope of inflections
- Architectures for morphology-syntax-semantics interface
- Morphosyntax: with words or morphemes?
- Morphosyntactic types
- Lexical representation of free/bound morphemes
- Sample derivations of the parser (and performance)
Derivational morphology

- **bracketing mismatches** were first noted in derivational morphology (Williams, 1981)

![Diagram of Gödel number and -ing]

- Gödel number

- Gödel
  - number
  - -ing
Verbal inflection

- The problem arises in inflectional morphology as well

- **West Greenlandic** (Fortescue, 1984)

  Aatsaat tikeraa-nngi-laq
  for.first.time visit-NEG-INDIC/3s
  ‘It is not the first time he has visited.’

- It does not mean ’This is the first time he failed to visit.’
Coordination

- **German** (Müller, 1999)

Wenn *Ihr Lust und noch nichts anderes vor-habt*,
if *you pleasure and yet nothing else intend*

können wir sie ja vom Flughafen abholen
*can we them PARTICLE from. the airport pick up*

‘If you feel like it and have nothing else planned, we can pick them up at the airport.’

- **semantics:** Ihr Lust habt UND noch nichts anderes vorhabt
Subordination

- **Turkish**

Mehmet Ayşe’nin [duzenli uyu]-ma-ma-sı-na kız-iyor
M.NOM A.-GEN regularly sleep-NEG-INF-AGR-DAT anger-TENSE
’Mehmet is angry with Ayşe for not sleeping regularly.’

not ’Mehmet is constantly angry with Ayşe for not sleeping.’

Mehmet Ayşe’nin kitab-ı oku-ma-sı-nı iste-di
M.NOM A.-GEN book-ACC read-INF-AGR-ACC want-TENSE
’Mehmet wanted Ayşe to read the book.’

- **semantics:** want (read book ayse) mehmet
Relativization

- **Turkish** (Bozsahin, 2002)

- Local and non-local morphosyntactic requirements of rel. noun may be different

Ben Mehmet’ın çocuğ-a/*-u ver-diğ-i kitab-ı oku-du-m
I.NOM M-GEN child-DAT/*ACC give-REL.OP book-ACC read-TENSE-PERS1
’I read the book that Mehmet gave to the child.’

Ben Mehmet’ın kitab-ı ver-diğ-i çocuğ-u/*-a gör-dü-m
I.NOM M-GEN book-ACC give-REL.OP child-ACC/*DAT see-TENSE-PERS1
’I saw the child to whom Mehmet gave the book.’
Lexemic vs. morphemic lexicons

ver-diğ-i :=

\[
\begin{align*}
&\text{LOCAL} \\
&\text{CONTENT} \\
&\text{NONLOCAL} \mid \text{TO-BIND} \mid \text{SLASH}\{\text{II}\} \\
&\text{SUBCAT} \quad <\text{NP[gen]}, 2\text{NP[acc]}, 1\text{NP[dat]} > \\
&\text{MOD} \mid \text{MODSYN} \mid \text{LOCAL} \mid \text{CONT} \mid \text{INDEX} \quad 1 \\
&\text{RELN} \\
&\text{GIVER} \quad 3 \\
&\text{GIVEE} \quad 1 \\
&\text{GIFT} \quad 2 \\
&\text{HEAD} \\
&\text{AGR} \\
&\text{PERSON} \quad 3 \\
&\text{NUMBER} \quad 1 \\
&\text{AGR} \\
&\text{CASE} \\
&\text{third} \\
&\text{sing} \\
&\text{dat} \\
\end{align*}
\]
\[-\ddag \text{-i} := \]
\[
\begin{array}{c}
\text{LOCAL} \\
\text{CAT} \\
\text{CONTENT} \\
\text{NONLOCAL} | \text{INHER} | \text{SLASH} \\
\end{array}
\]

\[
\begin{array}{c}
\text{HEAD} \quad \text{noun}[\text{acc} \text{ or dat}] \\
\leftrightarrow \\
\text{npro} [\text{INDEX} | \Psi] \\
\end{array}
\]
Nominal inflection

- Morphological richness of the language does not seem to be the issue

- English (Carpenter, 1997)

  four **truck-s**

  **semantics:** four (plu truck)

  **alleged thiev-es**

  **semantics:** plu (alleged thief),  **not** alleged (plu thief)
Resolving the mismatch

- **semantic combinatorics** may require affixes to have scope larger than the inflected word

- Alternatives for the morphology-syntax-semantics interface
  - Autonomous levels of morphology, syntax, and semantics (e.g. Sadock, 1991)
  - Morphosyntax-driven semantics (Heylen, 1997; Bozsahin, 2002)

- The lexicon can be **morphemic** in either case, but it is a **combinatory morphemic lexicon** in a more lexicalist approach
Inflectional morphology & linguistic theory

- GB (Anderson, 1982) and LFG (Bresnan, 1995) consider inflectional morphology to be part of syntax, (in GB, it is not part of combinatory aspects of grammar)

- MP (Chomsky, 1995) assumes words enter syntax fully inflected (numeration)

- HPSG (Pollard & Sag, 1994) keeps it in the lexicon (lexical rules, or lexical inheritance hierarchy)

- CG work in general (Hoffman, 1995; Heylen, 1997; and others) assumes word-based lexicons, although this is not a theoretical commitment
TLG and inflectional morphology

- Heylen’s (1997, 1999) unary modalities. \( \text{Frau} := \square_{\text{case}} \square_{\text{fem}} \square_{\text{sg}} \square_{\text{3p}} \square_{\text{decl}} \mathcal{N} \)

- Morphosyntactic type assignment is to inflected forms

- Structural rules regulate scope of inflections, e.g. \( \square_{\text{sg}} \square_{\text{case}} \mathcal{N} \) can be turned into \( \square_{\text{case}} \square_{\text{sg}} \mathcal{N} \) by a structural rule

- Some iterative morphological processes challenge the lexical rules for word-based type assignment (e.g. -ki in Turkish)

- A more lexical solution is to have morphemic lexicons and morphosyntactic calculus (i.e. -ki as lexical item)
Syntactic types

• syntactic categories and features

\[ N, NP, S \]

feature-decorations, \( NP_{acc}, S_{fin} \)

• But features as such are not part of combinatorics,

unlike e.g. \( NP_{case} \rightarrow \text{Det N Case} \)
Syntactic calculus

Application (<): \[ Y : a \quad X \backslash Y : f \quad \Rightarrow \quad X : f \ a \]

Composition (>B): \[ X / Y : f \quad Y / Z : g \quad \Rightarrow \quad X / Z : \lambda x . f (g x) \]

Type Raising (>T): \[ X : a \quad \Rightarrow \quad T / (T \backslash X) : \lambda f . f [a] \]

Leftward Contraposition (<XP): \[ X : a \quad \Rightarrow \quad S_{+t} / (S / X) : \lambda f . f [a] \]
\[ S_{+t} / (S_{+t} / X) : \lambda f . f [a] \]

Rightward Contraposition (>XP): \[ X : a \quad \Rightarrow \quad S_{-t} \backslash (S \backslash X) : \lambda f . f [a] \]
\[ S_{-t} \backslash (S_{-t} \backslash X) : \lambda f . f [a] \]
Morphosyntactic types

- Two kinds of unary modalities on syntactic types
  
  \( ^a \triangleleft X \) (flexible morphosyntactic domain for \( X \) : “up to certain inflectional type”)

  \( ^\bowtie X \) (strict domain: “require certain inflectional type”)

- If inflectional paradigm is Stem-Number-Case,

  \( ^\bowtie N \) stands for case-marked nouns

  \( ^c \triangleleft N \) stands for noun stems, number-marked, and case-marked nouns
• Lattice $L = (\mathcal{D}, \leq, =)$

• The set of basic morphosyntactic types: $\mathcal{A}_{ms}$

  $\downarrow i X \in \mathcal{A}_{ms}$ and $\diamondsuit X \in \mathcal{A}_{ms}$ if $i \in \mathcal{D}$ and $X \in \mathcal{A}_s$ ($\mathcal{A}_s$: syntactic types)

• The set of complex morphosyntactic types: $\mathcal{B}_{ms}$

  $\mathcal{A}_{ms} \subseteq \mathcal{B}_{ms}$

  If $X \in \mathcal{B}_{ms}$ and $Y \in \mathcal{B}_{ms}$, then $X\backslash Y$ and $X/Y \in \mathcal{B}_{ms}$
Lattice of diacritics (inflectional types)

- Inclusion of domains is specified in a language-particular lattice

  This comes in handy for specifying morphotactics as well

- More importantly, it allows morphosyntactic types to pick semantic domains independent of surface attachment

- All of this is specified in the lexical entry

  attachment type, morphosyntactic type, diacritic, semantic type
Morphosyntactc lexicon & grammar

- \(-\text{PLU} := a \circ s - n \triangleleft N \triangleleft b N: \lambda x.\text{plu} x\)

- Forward Application (\(\rightarrow\)):

\[
\begin{align*}
\circ s_1 & \rightarrow X / \alpha_1^i Y: f \\
\circ s_2 & \rightarrow \alpha_2^j Y: a \\
\circ (s_1 \bullet s_2) & \rightarrow X: fa
\end{align*}
\]

if \(\alpha_2 \sqcap_1 \alpha_1\) in lattice \(L\), for:

- \(\sqcap_1, \sqcap_2 \in \{\sqcap, \triangleleft\}\),
- \(\alpha_1, \alpha_2 \in D\) in \(L\),
- \(i, j, k \in \{a, s, c\}\),
- \(\circ_i \circ_j \vdash_a \circ_k\)
four  boy  -s

\[ n \downarrow N / n \uparrow N \]
\[ b \downarrow N \]
\[ n \downarrow N \backslash b \downarrow N \]

\[ n \uparrow N: \text{plu boy} \]

\[ n \downarrow N: \text{four(boy)} \]

four  boy  -s

\[ n \downarrow N: \text{four boy} \]

because n-base \( \neq \) n-num

\[ n \downarrow N: * \text{plu(four boy)} \]
toy     gun     -s

\begin{align*}
\triangleright N / \triangleleft N & \quad \triangleright N: \text{plu gun} \\
\end{align*}

\begin{align*}
\triangleright N \text{: *toy(plu gun)} \\
\text{because } n\text{-num} \not\subseteq n\text{-base}
\end{align*}

\begin{align*}
\triangleright N / \triangleleft N & \quad \triangleright N \quad \triangleleft N \quad \triangleleft N \\
\triangleright N: \text{toy gun} \\
\end{align*}

\begin{align*}
\triangleright N \text{: plu(toy gun)}
\end{align*}
'This is not the first time he visited.'
Aatsaat
for.the.first.time
tikeraa
visit
-nngi
-NEG

\((i \triangleright S \triangleright f \triangleright NP)/(i \triangleright S \triangleright f \triangleright NP)\)

\(v \triangleright S \triangleright f \triangleright NP\)

\(\triangleright S \triangleright f \triangleright NP\)

because \(n \not\leq i\)
'The child forgot to give the pen to the girl.'
'Themantowhomthechildgavethebookslept.'
completely destroy -ed

\[ (\langle S \langle f \text{ NP}/ \langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ \langle S \langle f \text{ NP}/ \langle f \text{ NP} \rightarrow B \\
\langle S \langle f \text{ NP}/ \langle f \text{ NP} \leftarrow B \times \\
\langle S \langle f \text{ NP}/ \langle f \text{ NP} \]

*completely did destroy

\[ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ (\langle S \langle f \text{ NP}/ \langle S \langle f \text{ NP}/ \langle f \text{ NP} \rightarrow B \\
\langle S \langle f \text{ NP}/ \langle f \text{ NP} \]

because \( t \nless v \)
did destroy completely

\[
(\overset{t}{S} \overset{f}{NP})/ (\overset{v}{S} \overset{f}{NP}) \rightarrow (\overset{v}{S} \overset{f}{NP})/ \overset{f}{NP} \rightarrow (\overset{v}{S} \overset{f}{NP})/ (\overset{v}{S} \overset{f}{NP})<B_x
\]

\[
(\overset{v}{S} \overset{f}{NP})/ \overset{f}{NP} \rightarrow (\overset{t}{S} \overset{f}{NP})/ \overset{f}{NP} \rightarrow (\overset{v}{S} \overset{f}{NP})/ (\overset{v}{S} \overset{f}{NP})<B_x
\]

\[
(\overset{t}{S} \overset{f}{NP})/ \overset{f}{NP} \rightarrow (\overset{v}{S} \overset{f}{NP})/ (\overset{v}{S} \overset{f}{NP})<B_x
\]
Experiments with the CKY parser

- a 21-morpheme sentence (12 words) parsed in 2.9 seconds
  
  37-morphemes (20 words) in 40 seconds

- Güngördü & Oflazer’s LFG parser takes 10 seconds/sentence with 24,000 word lexicon

- separate morphological analyzers deliver 2 to 5 analyses/second (Oflazer, 1996; Komagata, 1997)

- 2.8 morphemes/word on the average including derivations (Turkish)
  
  less than 2 inflections/word (Oflazer et. al, 2001)
<table>
<thead>
<tr>
<th>Sample text type</th>
<th>Number of items in text</th>
<th>Avg. number of parses/gram. input</th>
<th>Avg. CPU time per test (milliseconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tests</td>
<td>words</td>
<td>morphs</td>
</tr>
<tr>
<td>Word order &amp; case</td>
<td>58</td>
<td>216</td>
<td>384</td>
</tr>
<tr>
<td>Subordination</td>
<td>14</td>
<td>70</td>
<td>137</td>
</tr>
<tr>
<td>Relativization</td>
<td>23</td>
<td>130</td>
<td>232</td>
</tr>
<tr>
<td>Control verbs</td>
<td>33</td>
<td>147</td>
<td>291</td>
</tr>
<tr>
<td>Possessives &amp; compounds</td>
<td>26</td>
<td>109</td>
<td>200</td>
</tr>
<tr>
<td>Adjuncts</td>
<td>14</td>
<td>57</td>
<td>100</td>
</tr>
<tr>
<td>-ki relatives</td>
<td>24</td>
<td>66</td>
<td>179</td>
</tr>
</tbody>
</table>
Conclusion

- The key to integration of inflectional morphology and syntax is granting representational status to morphemes

- Morphosyntactic mismatches do not necessitate multi-tiered grammars

- Lexical items can be smaller or larger than words, and project their own semantic domains and attachment characteristics

- Loss of efficiency is tolerable up to medium-length sentences

- Modular grammar-lexicon