The Problem of Long-Range Dependencies

• A central problem for a theory of grammar:
  – “elements of sentences which belong together at the level of semantics or interpretation may be separated by unboundedly much intervening material” (Steedman)

• Obvious example in English is the relative clause construction:
  – a woman whom Warren likes
  – a woman whom Dexter thinks that Warren likes
  – ...
The Relative Clause Construction

- Relative clause construction:
  - a woman whom Warren likes

  \[
  \begin{array}{cccc}
  a \text{ woman} & \text{whom} & \text{Warren} & \text{likes} \\
  \text{NP} & ? & \text{NP} & (S\backslash\text{NP})/\text{NP} \\
  \end{array}
  \]

- whom Warren likes should be $\text{NP} \backslash \text{NP}$
- so whom should be $(\text{NP} \backslash \text{NP})/X$ for some $X$ to be determined
• Could *Warren likes* be a constituent?
• The coordination test for constituency suggests so:
  – *Warren likes but Dexter detests contemporary dance*
• So what is its type?
  – how about *S/NP*?
  – in which case the type of *whom* is *(NP/NP)/(S/NP)*
### Deriving “Non-Constituents”

<table>
<thead>
<tr>
<th>a woman</th>
<th>whom</th>
<th>Warren</th>
<th>likes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP</td>
<td>(NP\NP)/(S/NP)</td>
<td>NP</td>
<td>(S\NP)/NP</td>
</tr>
</tbody>
</table>

- Can’t combine *Warren* and *likes* using application rules
- Need two new rules: type-raising and composition
Type-Raising

- Subject $NP$ becomes a functional category
- In general: $NP \Rightarrow T/(T\backslash NP)$
  - $T$ is a variable; in practice, for both linguistic and practical parsing reasons, we’d want to limit $T$ to a particular set of types
- Other categories can be type-raised, too, and we can have backward, as opposed to forward, type-raising
Forward Composition

- Composition allows us to “get inside” a functional category
- In general: \( X/Y \ Y/Z \Rightarrow X/Z \)
The Complete Derivation for the Object Relative Clause
• Used for other syntactic constructions as well, e.g. “non-constituent” coordination (see JHU tutorial slides for the right-node raising example)

• There are other forms of type-raising and composition rules (more on this later)

• *Combinatory* Categorial Grammar is so-called because of the correspondence between CCG’s rules and some of the rules in Combinatory Logic (Curry and Feys)
Type-raising and composition can be used to analyse simple sentences with no long-range dependencies

A different derivation results, *but the interpretation is the same* (hence so-called “spurious ambiguity”)

In practice we deal with the extra ambiguity by treating it like all other, non-spurious ambiguity (and we still get a highly efficient parser)