1. Sentence Processing

Syntax tells us that sentences have a structure, but it doesn't tell us how that structure is used. Is this one of syntax's downfalls? No!

Syntax is concerned with linguistic knowledge, and does not postulate what constitutes the behavior of individuals when using this knowledge.

Sentence processing, however, is concerned with language users' behavior. The parser (or human sentence processor) uses the grammar as well as additional rules to guide the comprehension of sentences. It has the following properties:

- **incremental**: Builds structure as the sentence is being heard. It does not wait until the full sentence has been heard to begin building structure.
- **left-to-right**: Builds structure from left to right.
- **robust**: Accurately processes previously unseen data.
- **sensitive to prior linguistic experience**: It can be trained.
- **informed by grammar**: The parser can not be fully explained by means of statistics or heuristics, but requires a component that specifies the grammar of the language.

Does syntactic structure affect sentence processing? Does sentence processing affect syntactic structure?

2. Ambiguity

Sentences can have more than one syntactic structure, as shown by the following (real) newspaper headlines:

- a) **HERSHEY BARS PROTEST**
- b) **CHOU REMAINS CREMATED**
- c) **ENRAGED COW INJURES FARMER WITH AX**

Structural ambiguity leads to different meanings for the same string of words, as shown by the prepositional phrase (PP)-attachment ambiguity in (2) for the sentence "John bought the book for Susan".
In 2a, the meaning of the sentence would be interpreted as "John bought the specific book for Susan" (nominal complement), whereas in 2b the meaning would be "John bought a book, and the book was for Susan" (verbal adjunct). The meaning difference is reflected by the different syntactic structures.

This leads to complications. If there are multiple possible interpretations for a sentence, how do we select the correct one? Is there a preference for one reading over another?

3. Garden pathing

Some sentences have a relatively simple syntactic structure, but they're very difficult for humans to understand, as in (3).

   a) The doctor sent for the patient arrived.
   b) The old train the young.
   c) The cotton clothing is made of grows in Mississippi.  

Frazier's (1979) garden pathing theory specifies that this difficulty results from the parser building an incorrect analysis that it can't recover from. For instance, when interpreting (3a), the parser wants to make "the doctor" the subject of the verb phrase "sent for the patient", as in (4a). But, when it gets to the word "arrived", it crashes because it can not attach this word anywhere. (4b) shows the correct analysis in the sentence, which corresponds to a reduced form of the phrase "The doctor who sent for the patient arrived".
a) Main-verb reading

\[
\text{IP} \quad \text{NP} \quad I' \quad \text{VP} \quad +\text{Pst} \quad ?
\text{the doctor} \quad \text{sent} \text{ for the patient} \quad \text{arrived}
\]

b) Reduced-relative reading

\[
\text{IP} \quad \text{NP} \quad I' \quad \text{VP} \quad +\text{Pst}
\text{the doctor} \quad \text{sent} \text{ for the patient} \quad \text{arrived}
\]

In other words, (4a) shows the syntactic structure the parser is building as it is being led down the garden path of the incorrect analysis.

Syntax can not explain why these sentences are unacceptable for most speakers (i.e., the structure in (4b) is perfectly grammatical). This is a performance issue and should be explained by the rules and procedures of the parser itself.

Some garden paths are more temporary than others. For example, native English speakers would not characterize the sentence in (5) as ungrammatical.

\[
\text{John knew the answer was wrong.}
\]

In (5), the NP "the answer" is the subject of the verb "was".

However, eye-tracking studies indicate there is an increase in processing time when the word "was" is encountered (Ferreira & Henderson 1990), signifying that the parser has some difficulty. (6) shows the average total reading time results for the different regions of subject-object ambiguity sentences based on Ferreira & Henderson's study.

\[
\begin{array}{c}
\text{John knew the answer was wrong} \\
264 \quad 276
\end{array}
\]

ambiguous region disambiguating region

This increase in processing time would be further supported by the hypothesized incremental interpretation of the sentence "John knew the answer was wrong", shown in (7).
According to Frazier (1979), this data can be explained by the following heuristics attributed to the human sentence processor.

**minimal attachment**  
Don't postulate new nodes unless you have to (e.g., 4b).

**late closure**  
Attach new words to the clause currently being processed (e.g., 3b).

**canonical sentoid strategy**  
Interpret N-V-N as S-V-O (e.g., 7c) (Fodor et al. 1974).

By employing heuristics like these, the parser is generally able to quickly and easily build correct structures for the majority of sentences. Garden path sentences fall outside this domain of acceptability.
4. PP-attachment, revisited

Parser heuristics also affect the interpretation of ambiguous sentences. For example, the two structures in (2) (repeated below in (8)) are syntactically equal. They have two different semantic meanings, but the syntax can not prefer one structure over another.

![Diagram of two syntactic structures](image)

(8) (Lewis 1993)

However, psycholinguistic studies have shown that the humans prefer the "high attachment" reading of the prepositional phrase, as in (8a). This preference can be explained by performance factors like Frazier's minimal attachment heuristic. The structure in (8a) introduces fewer nodes, and is therefore preferred by the parser.

Homework
Read sections 3.3 and 3.4 (pages 221-228) in the textbook.

References

