Structural analysis of expected and unexpected clauses in sentences
*using **gaze-tracking** studies*

Chirag Gupta

IIT Kanpur

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Introduction

- Consider the following sentences
  - ➢ The ball was kicked by Bhutia into the goal.
  - ➢ The ball was kicked into the goal by Bhutia.
  - ➢ Bhutia kicked the ball into the goal.

- Above sentences are all grammatically correct.

- Only the third one seems natural.

- First two sentences have an added adverbial clause, that could be avoided.
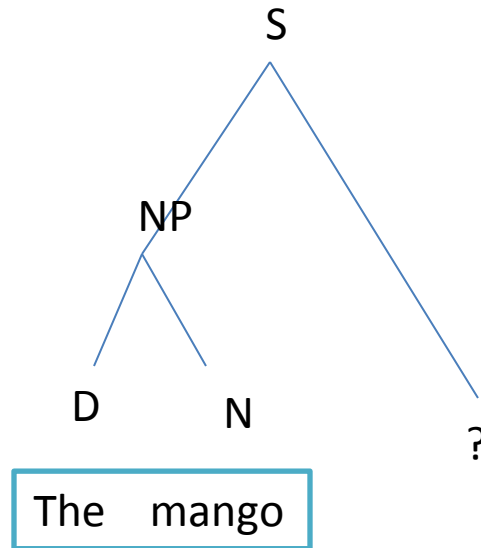
Incremental evaluation

- The brain constructs parse trees incrementally, or by looking at the local context of the phrase.

- How would the brain parse the following two sentences?
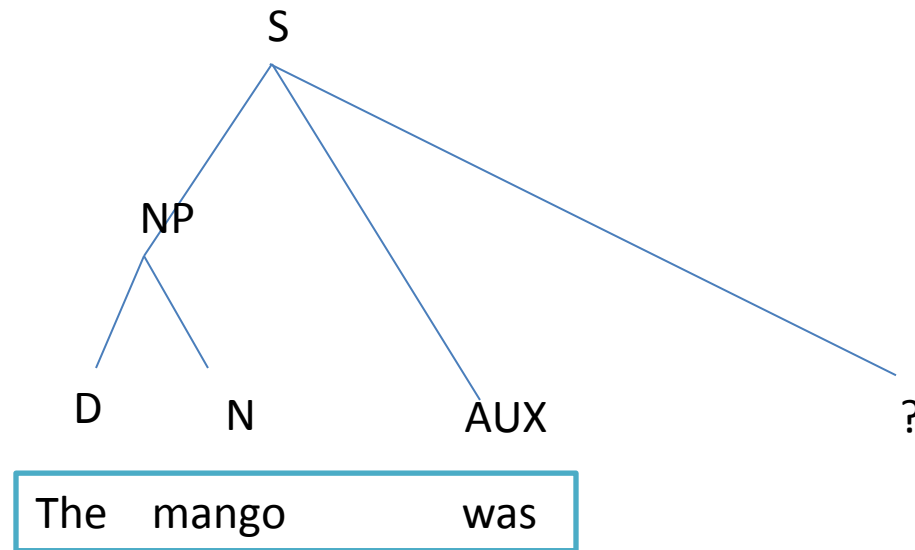
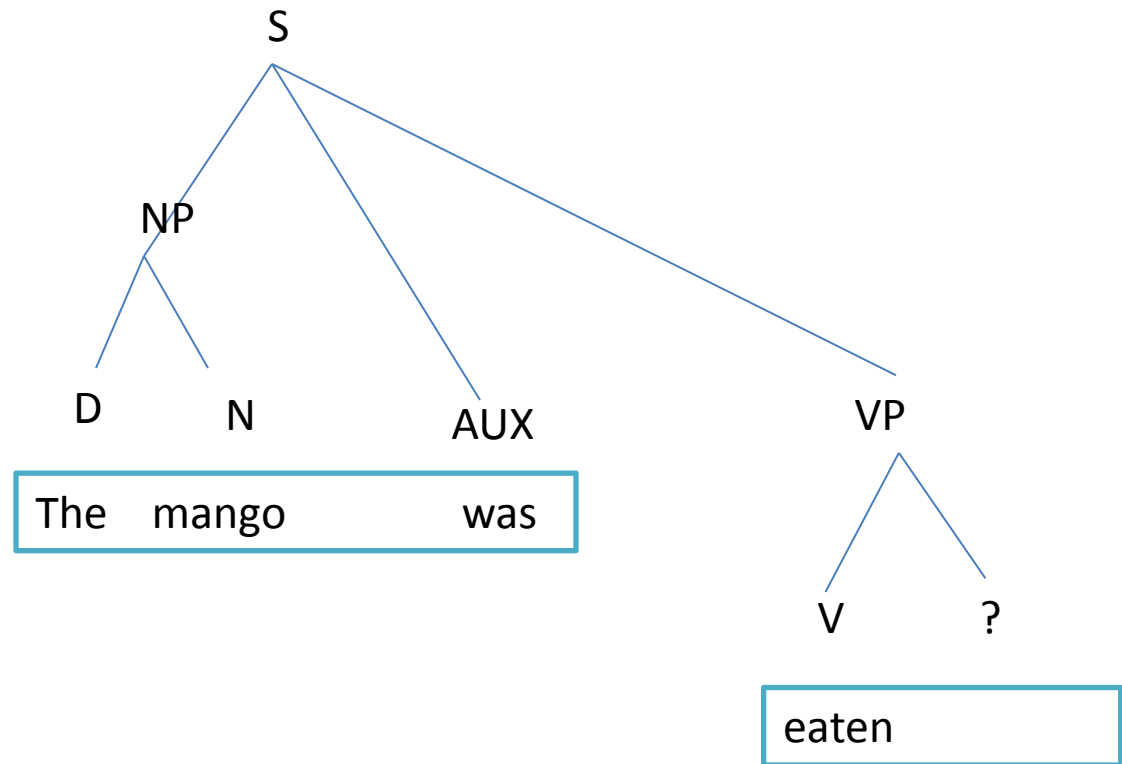- "The mango was eaten by Aniket"
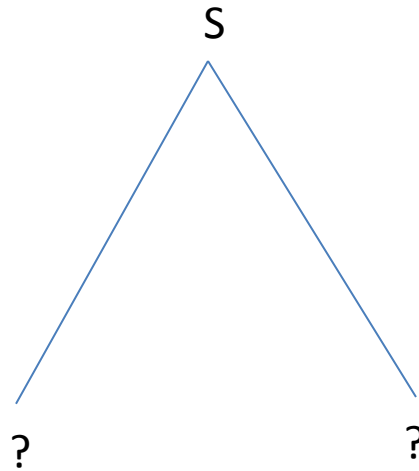
The mango was eaten by Aniket.

```
        S
       / \
      /   \
     /     \
    ?       ?
```

The mango was eaten by Aniket.

S
NP
D
N
?
The   mango

The mango was eaten by Aniket.

```
                        S
                       /|\
                      / | \
                     /  |  \
              NP    /   |   \
             / \   /    |    \
            /   \ /     |     \
           D     N     AUX     ?
        ┌─────────────────────────┐
        │ The   mango       was   │
        └─────────────────────────┘
```

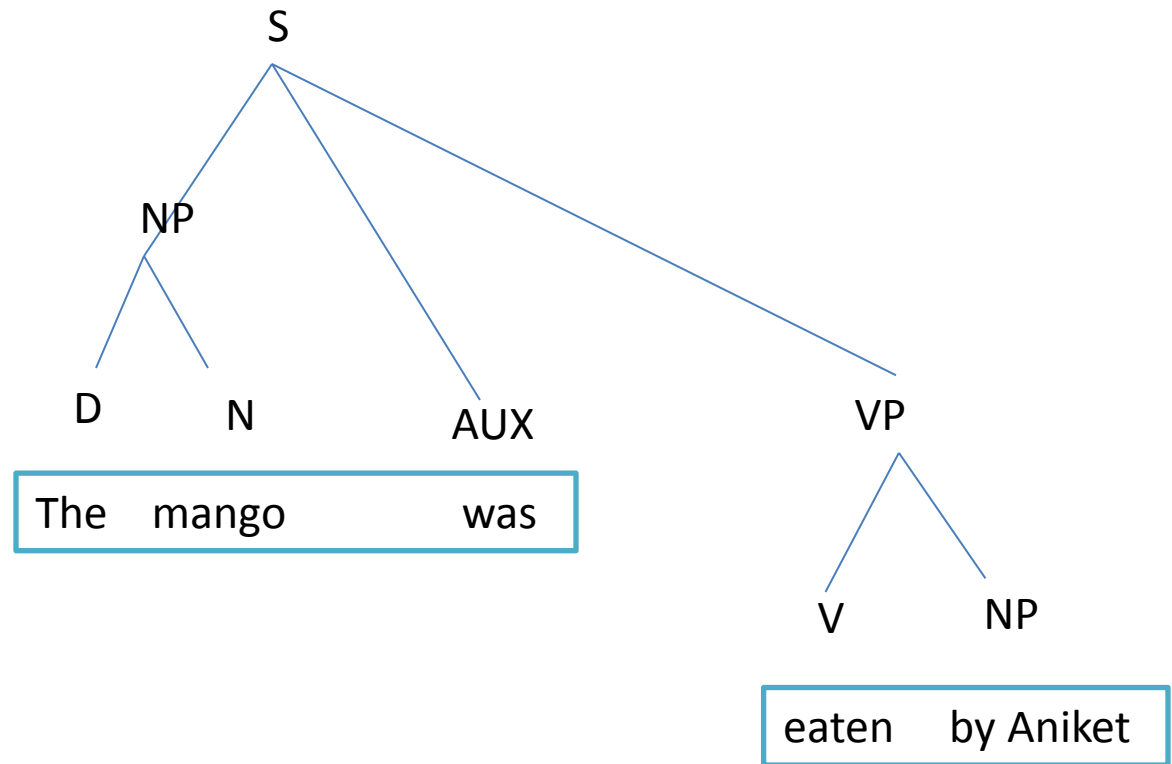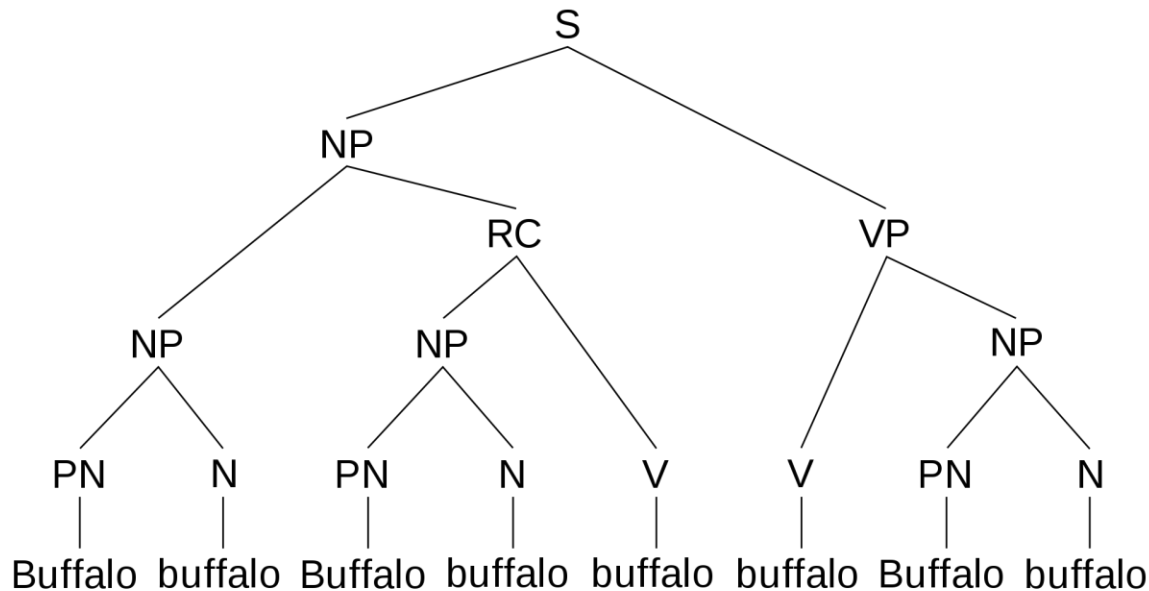# The mango was eaten by Aniket.

The mango was eaten by Aniket.

Ambiguities in incremental evaluation

- What happens with such sentences?

- "Buffalo buffalo Buffalo buffalo buffalo buffalo Buffalo buffalo"

Garden path sentences

- Definition : A grammatically correct sentence that starts off in such a way that a reader's interpretation using the most likely parse in incremental evaluation will be incorrect. The reader is lured into a parse that turns out to be a dead end.

Source: Wikipedia

- "As the police stopped the driver became very frightened"

Source: Pickering and Traxler, '98

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- In speech, ambiguities are much easier to resolve due to punctuation related inflections.

Disambiguation and reanalysis

- On hitting a clause that is unexpected with respect to the current analysis, a disambiguation occurs through reanalysis.

- These effects can be observed, in gaze-tracking studies, by statistical analysis of
  1. Regressions: moving from the current spot to a spot on the left.
  2. First pass time
  3. Overall fixation time.

- Note that parts 1 and 2 focus on a local clause, and are concerned with its plausibility, whereas part 3 deals with the sentence as a whole.

Study 1 (replication)

- Traxler and Pickering ('98) study the effect of garden path sentences have, using gaze tracking studies.

- Unnatural / unexpected parts of sentences will have larger *first pass time* and *regressions* as compared to naturally expected parts.

- Sentences that contain unexpected clauses will have a larger *total pass time*.

Subordinate-clause ambiguities

- "As the woman edited the magazine amused all the reporters"

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- Object analysis ('magazine') turns out to be wrong. 'Amused' indicates that it must be the subject of the verb phrase, and not the object of the noun phrase.

Attachment to a more plausible clause

- Pickering and Traxler ('98) noted that first pass time was longer if the first part of the clause was more plausible.

- Readers *'attached themselves more strongly'* to that clause.
  - As the woman edited the magazine amused all the reporters. (difficulty in reanalysis)
  - As the woman sailed the magazine amused all the reporters. (more easily reanalyzed)

Complement-clause ambiguities

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- "The criminal confessed his gang harmed too many people."

'Control' sentences

- As the woman edited the magazine amused all the reporters → As the woman edited, the magazine amused all the reporters

- The criminal confessed his sins harmed too many people → The criminal confessed that his sins harmed too many people

Proposition

- The above work also 'induces' the following two classes of sentences.

- Those that are plausible, and also have an expected structure **VS** those that are plausible, but have an unexpected structure.
  - The magician touched the boy with a wand.
  - The magician touched the boy with a ball.

- Both sentences completely natural, punctuated, and in their most canonical forms. Yet, the first one is more easily parsed.

Study 2 (proposed)

- What sentential structures are more natural?

- A paragraph containing around 15 sentences of *various syntactic forms*.

- All sentences grossly *plausible*.

- Pass time, and number of regressions measured for each sentence.

- Followed by an ANOVA on average reading time and variance across subjects, for various sentences.

References :

- "Plausibility and Recovery From Garden Paths: An Eye-Tracking Study", Pickering and Traxler '98

- "The time-course of the application of binding constraints in reference resolution", Sturt '03

- "Plausibility and the Processing of Unbounded Dependencies: An Eye-Tracking Study", Pickering and Taxler '98

- "Eye movements in reading and information processing: 20 years of research", Rayner and Keith '98

- "The On-line Study of Sentence Comprehension: Eyetracking, ERPs and Beyond", book by Manuel Carreiras '04