Surprise! Hallucinations of Garden-Path Sentences

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Hypotheses

- Linguistic information is used both proactively and retroactively
- The "good enough" theory of sentence processing is employed in the case of an encounter with a disambiguating word
- The relationship between surprisal and reading times is log-linear

Abstract

Garden-path sentences are those in which a local ambiguity biases the comprehender's incremental syntactic interpretation so strongly that upon encountering disambiguating input the correct interpretation can only be recovered with great effort, if at all! Our work goes over and above traditional garden-pathing to say that a "good-enough" parsing, inconsistent with the raw input but consistent with a slightly perturbed version of it causes 'hallucinations'! Such sentences show the same typical characteristis of garden-paths. Our self-paced reading experiment with simultaneous gaze tracking experiments seeks to validate our hypotheses mentioned above.

A Statistical Framework for Language

The surprisal theory suggests that the cognitive effort in reading a sentence is defined by

$$Effort(w_i) = \log \frac{1}{P(w_i | w_{1,2...i-1}, C_{txt})} \quad (1)$$

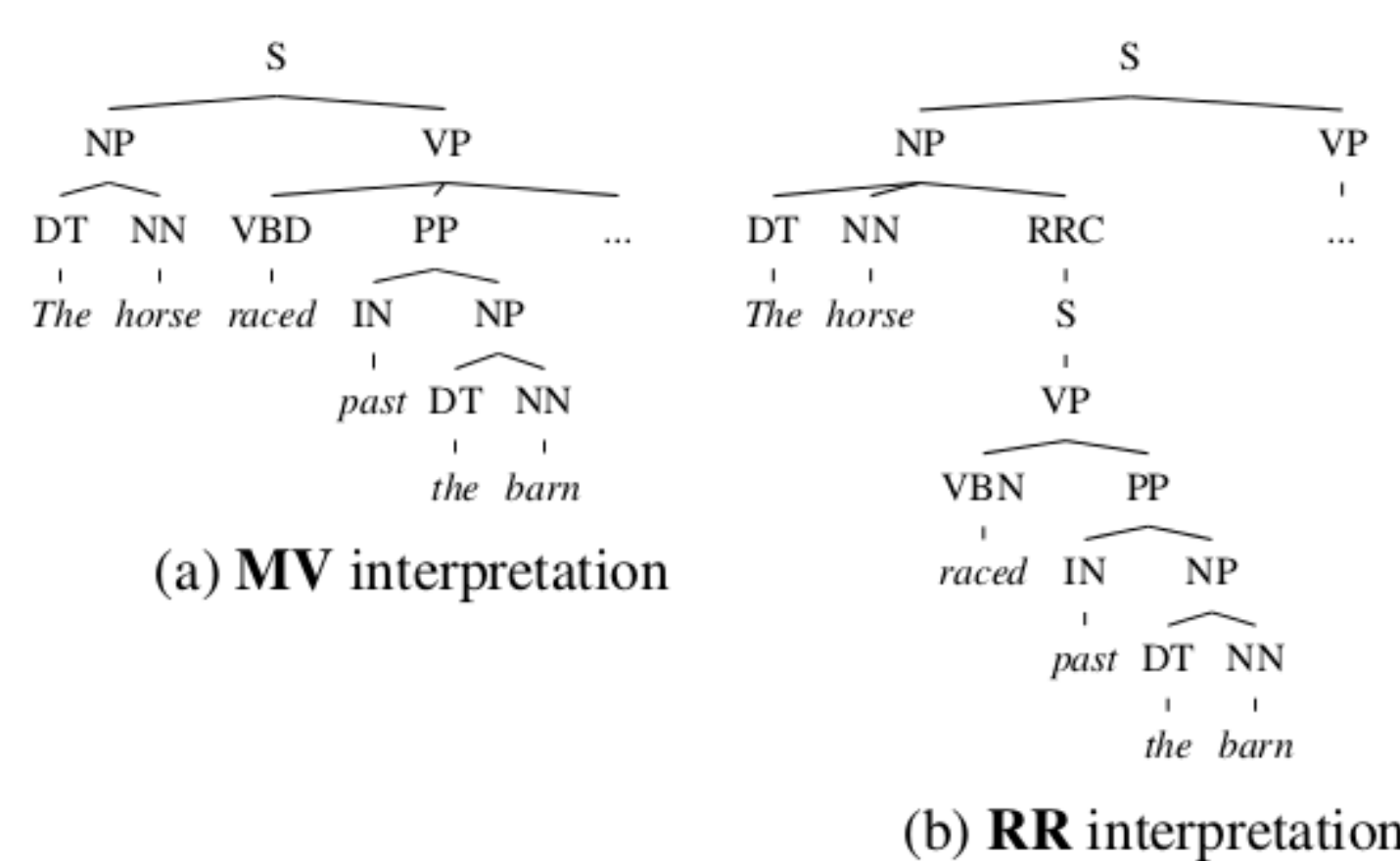(a) **MV** interpretation

(b) **RR** interpretation

Figure 1: "Good enough" (L) and Correct (R) Interpretation

Methods Part I - Reading Times

The first part of our experiment consists of a self-paced reading exercise, through the app we developed at http://home.iitk.ac.in/~sharbatc/se367/cogapp The participants were instructed to click on a button to reveal the subsequent word in a sentence.
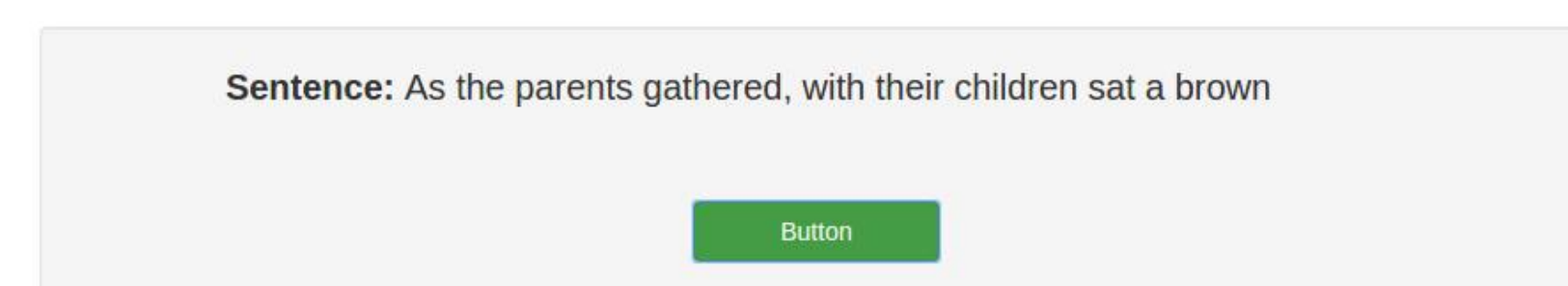
A yes/no question follows to test the comprehension of the semantics of the sentence by the reader.

The reading times between two clicks gives an idea about the difficulty of reading at each point.

Results I

Average reading time vs. the word was plotted for all the experimental items.
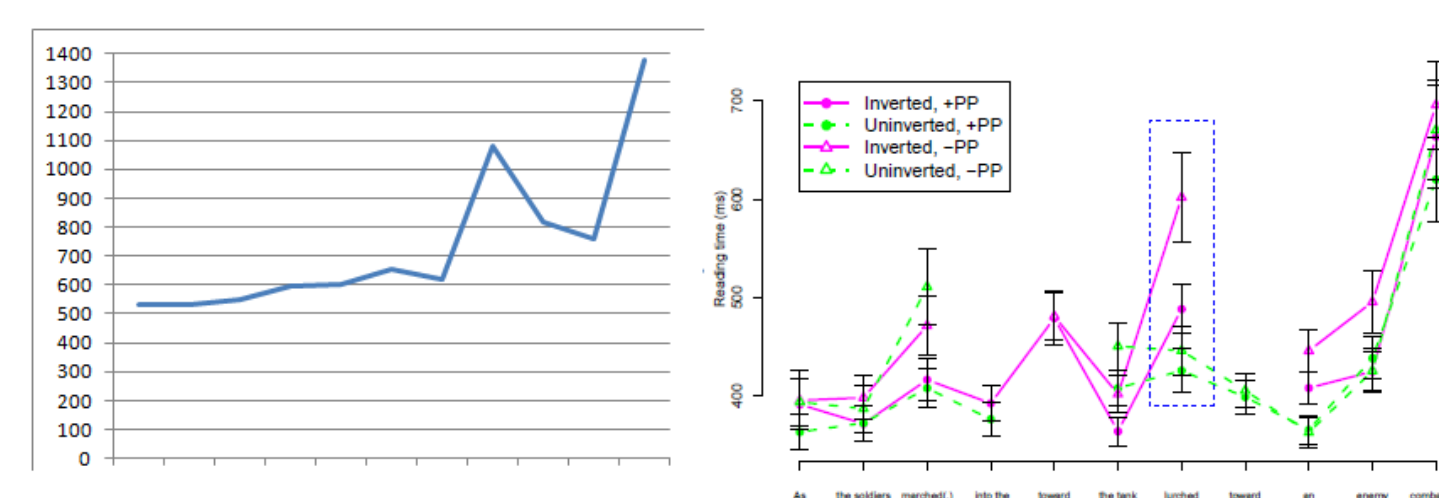

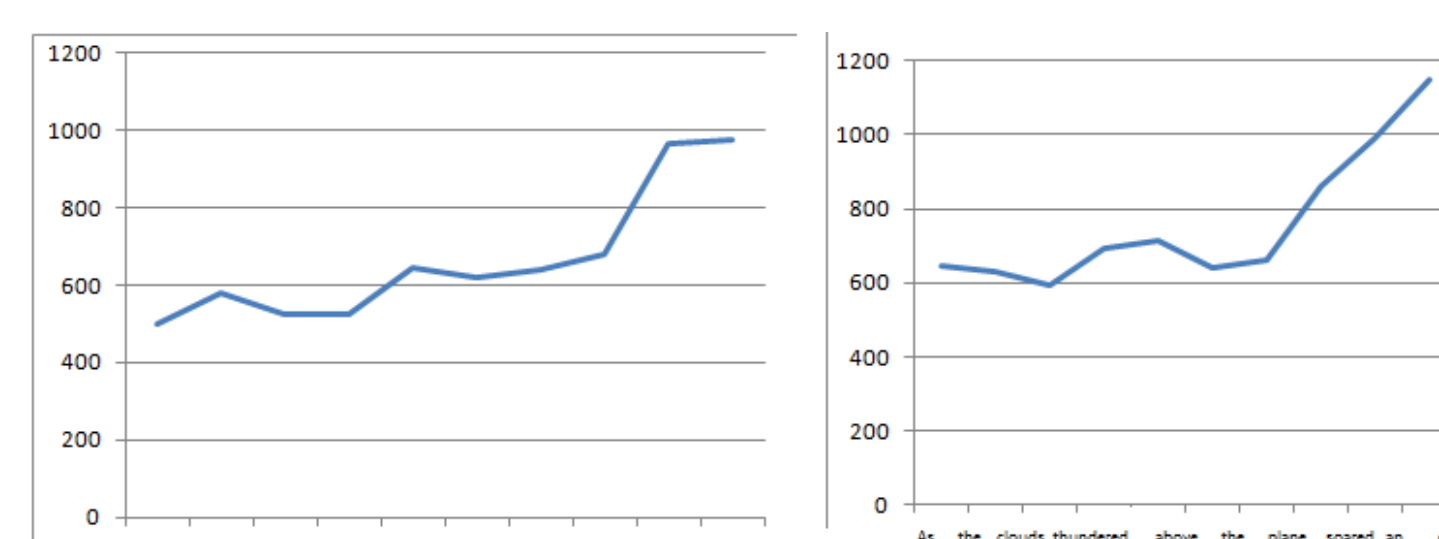Figure 3: Our (L) vs. Levy's Result

Figure 4: Classic (L) vs. Hallucinated Garden Pathing (R)

We also found considerable evidence to prove the "good enough" theory.

Sentence: *Lose the knot that was made.*
Question: *Are you instructed to loosen a knot?*
Yes: 71% No: 29%
Sentence: *As the clouds thundered, above the plane soared an eagle.*
Question: *Did the clouds thunder above the plane?*
Yes: 36% No: 64%

Methods Part II - Gaze Tracking

The second part of our experiment involves using a gaze tracking arrangement to track the gaze of a person presented with similar sentences used for the first part of our experiment.

- The saccades and the times between eye fixations at different points gives an idea of hallucinating garden path effect, as they should correlate with reading times.
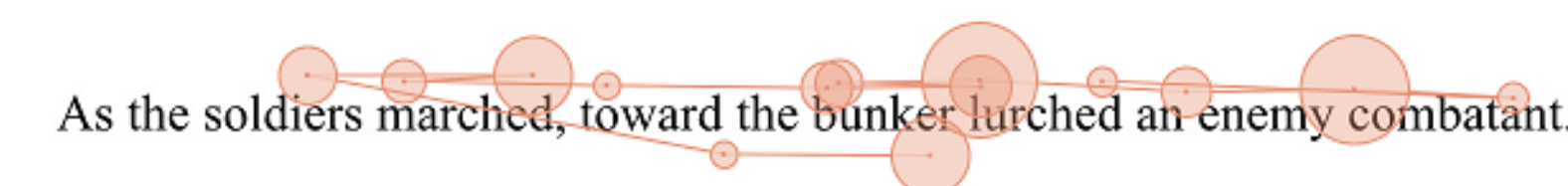

Figure 2: Example of a hallucinating garden-path

- The ignoring of the disambiguating factor (classic garden-path) can be understood by eye saccades and fixations.

Results II

The radius of the circle around each word is proportional to the saccade time.

Inferences

- Retroactive usage of the linguistic input is displayed quite clearly in case of examples like *Lose the knot that was made.*
- Subjects did display "Hallucinations", although not in the expected proportion. This, we attribute to a biased sample.
- Reading times were higher than those Levy had because our subjects were not native English speakers.

Garden Pathing in Indian Languages?

We thought of garden-path sentences in Indian languages (we looked at Hindi and Bengali) to test how speakers of one language parse sentences vis-a-vis others

- However, it is difficult to come up with such sentences in languages having a SOV structure, due to the disambiguating verb being at the end of the sentence.
- The examples we found were those that dealt with poetic language - difficult to comprehend as such.
- Lack of data points and subjects.

References

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