Using Nonsense Word Detection to Investigate Sentence Processing

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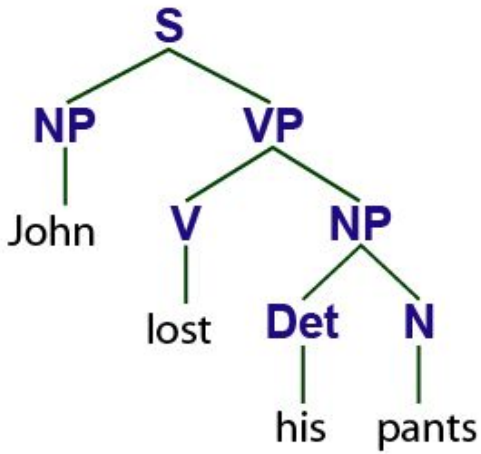
Sentence Processing

Sentence processing == Syntactic processing

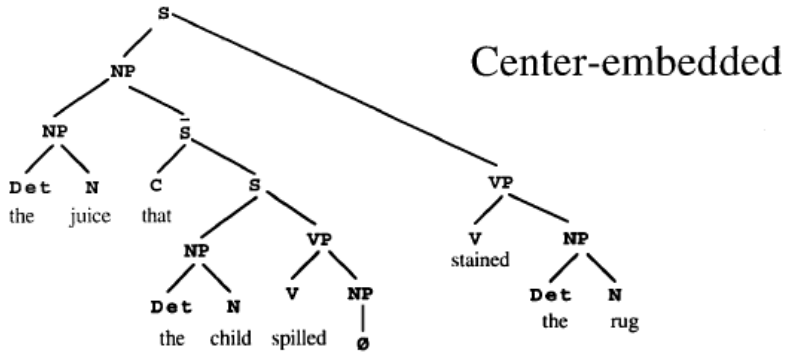


Nonsense Word Detection

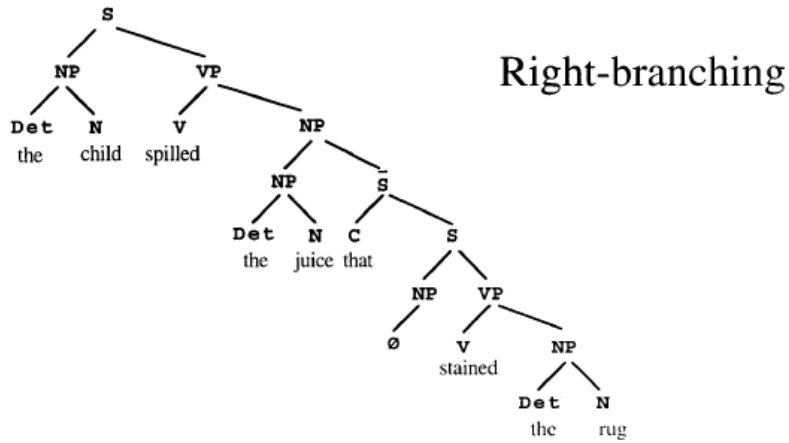
- Task:
  - Whole sentence presentation, one at a time
  - Did the sentence contain a nonsense word?
- Nonsense words == pseudo-words
  - Orthographically and phonologically plausible
  - e.g., *blim*, *cratomized*
- Only lexical words were replaced
  - Nouns $\rightarrow$ nonsense nouns
  - Verbs $\rightarrow$ nonsense verbs

Expt 1: Stromswold, et al. (1996)

- Participants:
  - 24 native and monolingual English-speaking college students
- Stimuli – Sentence Structures:
  - SO *The juice that the child spilled stained the rug*
    - i.e. center-embedded
  - OS *The child spilled the juice that stained the rug*
    - i.e. right-branching



Center-embedded construction: The juice that the child spilled __ stained the rug



Right branching construction: The child spilled the juice that __ stained the rug

- Participants:
  - 24 native and monolingual English-speaking college students
- Stimuli – Sentence Structures:

  SO *The juice$_1$ that the child$_2$ spilled$_3$ stained$_4$ the rug$_5$*
  OS *The child$_1$ spilled$_2$ the juice$_3$ that stained$_4$ the rug$_5$*
- Stimuli – Nonsense Word Positions:
  - Lexical word position#: 2, 3, 4, 5
  - Example:

    SO-3 *The juice that the child cratomized stained the rug*
    OS-3 *The child spilled the blim that stained the rug*

- Design:
  - $N = 144$ sentences
  - IV1 – Sentence structure
    - SO and OS
    - 72 sentences per structure type
  - IV2 – Nonsense word position
    - 72 sentences contained no nonsense word – Condition "NN"
    - 18 sentences per nonsense word positions: 2, 3, 4, and 5

- Procedure:
  - Participants saw whole sentences, one at a time
  - Did the sentence contained a nonsense word?
  - Reading Time and Accuracy were recorded

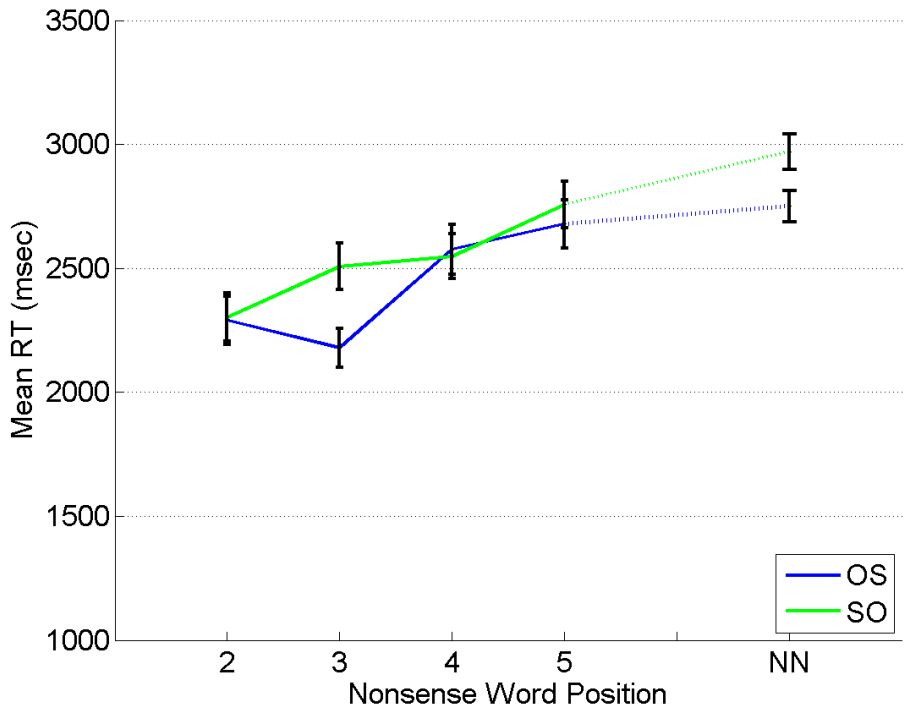
Results

- Participants responded with 95% accuracy
- We analyzed correct trials only

- Including no nonsense word cases:
  - Main effect of structure: $F(1, 23) = 5.84; p < .05$
  - Main effect of position: $F(4, 92) = 11.75; p < .001$
  - Interaction: $F(4, 92) = 2.96; p < .05$

- Only nonsense word cases:
  - Main effect of structure: $F(1, 23) = 4.27; p = .05$
  - Main effect of position: $F(3, 69) = 14.61; p < .001$
  - Interaction: $F(3, 69) = 3.26; p < .05$

Interaction Plot



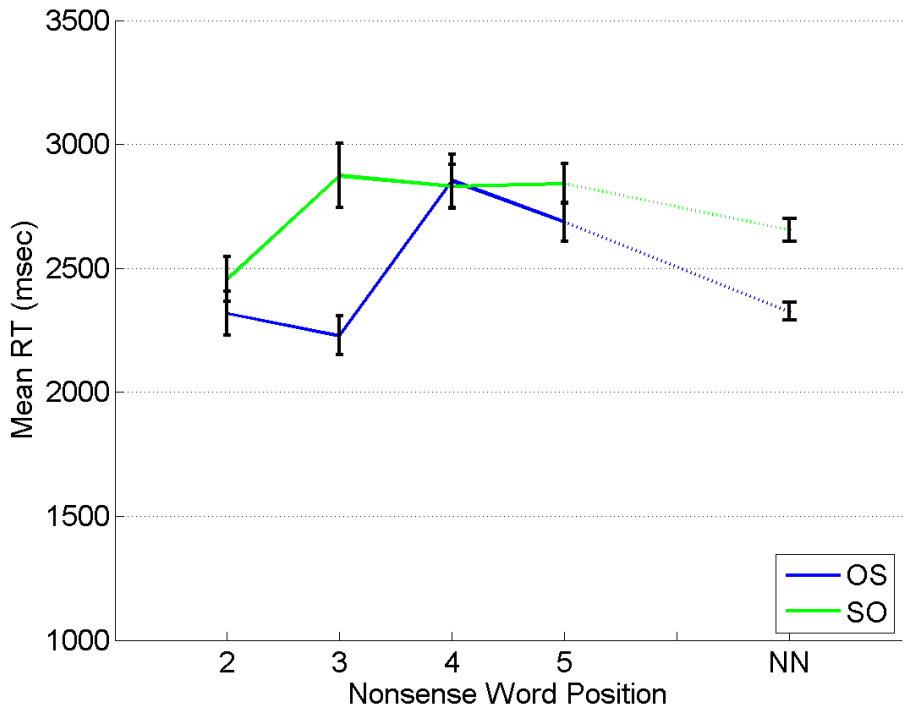
OS *The child*$_1$ *spilled*$_2$ *the juice*$_3$ *that stained*$_4$ *the rug*$_5$

SO *The juice*$_1$ *that the child*$_2$ *spilled*$_3$ *stained*$_4$ *the rug*$_5$

Expt 2: Replication in 2011

- Participants:
  - 25 native and monolingual English-speaking college students
- The experiment was replicated with the same design
- Participants responded with 93% accuracy
- Again, only correct trials were analyzed
- Including no nonsense word cases:
  - Main effect of structure: $F(1, 24) = 43.29; p < .001$
  - Main effect of position: $F(4, 96) = 7.38; p < .001$
  - Interaction: $F(4, 96) = 5.92; p < .001$
- Only nonsense word cases:
  - Main effect of structure: $F(1, 24) = 26.71; p < .001$
  - Main effect of position: $F(3, 72) = 10.12; p < .001$
  - Interaction: $F(3, 72) = 5.83; p < .005$

Interaction Plot



OS *The child*$_1$ *spilled*$_2$ *the juice*$_3$ *that stained*$_4$ *the rug*$_5$

SO *The juice*$_1$ *that the child*$_2$ *spilled*$_3$ *stained*$_4$ *the rug*$_5$

Put Together

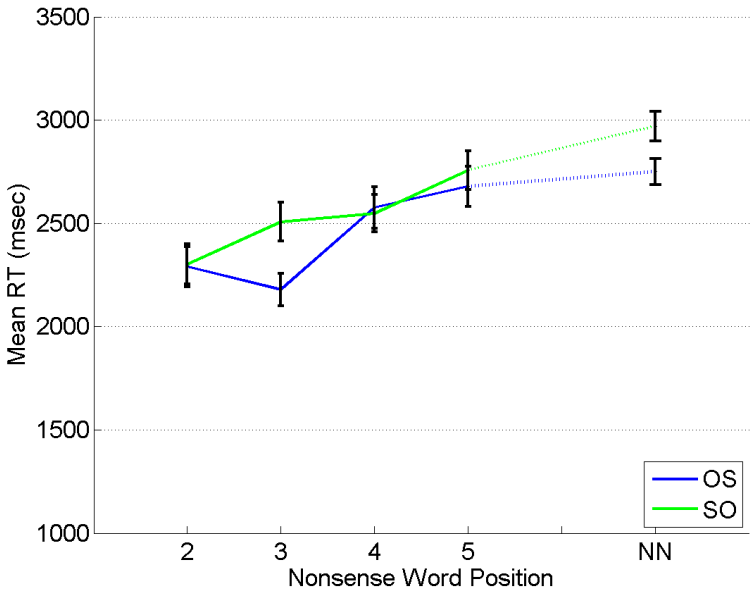


Figure 1: 1996

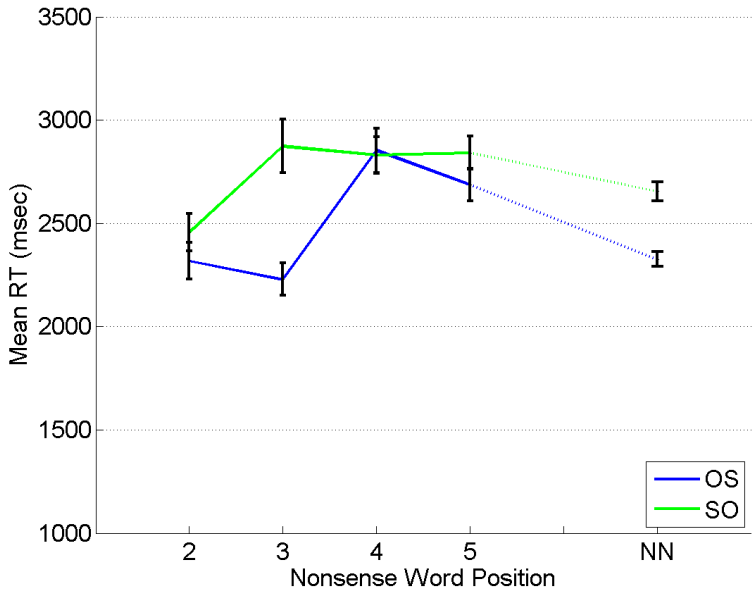


Figure 2: 2011

OS *The child$_1$ spilled$_2$ the juice$_3$ that stained$_4$ the rug$_5$*

SO *The juice$_1$ that the child$_2$ spilled$_3$ stained$_4$ the rug$_5$*

Discussion

- Both experiments suggest participants "parsed" the sentences
  - . . . even though the task did not require it
- There seems to be a difference between "early" and "late" nonsense word positions
  - Participants are possibly "parsing" till the end for "late" nonsense word positions

Lack of Structural Variability

- The lack of structural variability – only 2 sentence structures – is a serious limitation in the previous 2 experiments
- It is possible that participants adopted a task-specific strategy to deal with the two sentence structures
- Therefore, we ran another experiment with a greater number of sentence structures
  - 4 target structures + 10 filler structures

Expt 3: 2012

- Participants:
  - 26 native and monolingual English-speaking college students
- Stimuli – Sentence Structures:
  - 60 quadruplets of RC sentences:

SS *The actor who impressed$_2$ the critic$_3$ humiliated$_4$ the director$_5$*
SO *The actor who the critic$_2$ impressed$_3$ humiliated$_4$ the director$_5$*
OS *The director humiliated$_2$ the actor$_3$ who impressed$_4$ the critic$_5$*
OO *The director humiliated$_2$ the actor$_3$ who the critic$_4$ impressed$_5$*

- Stimuli – Nonsense Word Positions:
  - Lexical word position#: 2, 3, 4, 5

- Design:
  - $N = 240$ sentences
    - 60 target + 180 filler sentences
  - IV1 – Sentence structure
    - SO, SS, OO, and OS
    - 15 sentences per structure type
  - IV2 – Nonsense word position
    - 12 sentences contained no nonsense word – Condition "NN"
    - 12 sentences per nonsense word positions: 2, 3, 4, and 5
    - Half the fillers contained no nonsense words

- Procedure:
  - Participants saw whole sentences, one at a time
  - Did the sentence contained a nonsense word?
  - Reading Time and Accuracy were recorded

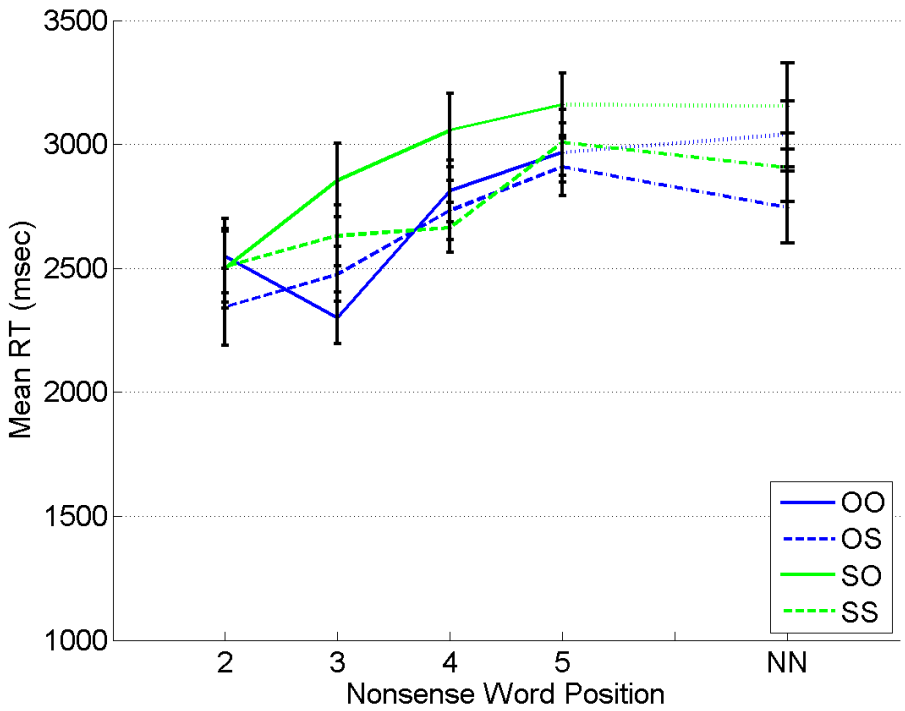
Results

- Participants responded with 95% accuracy
- We only analyzed trials to which participants correctly responded

- Including no nonsense word cases:
  - Main effect of structure: $F(3, 75) = 5.24; p < .005$
  - Main effect of position: $F(4, 100) = 8.34; p < .001$
  - Interaction: $F(12, 300) = 1.22; p = .27$

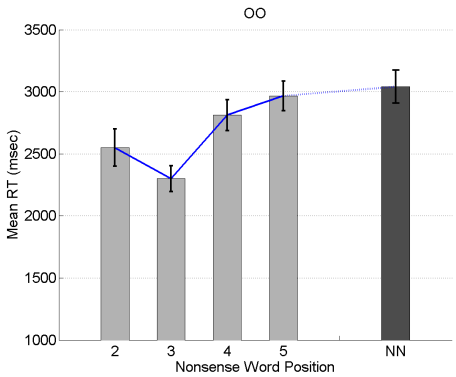
- Only nonsense word cases:
  - Main effect of structure:$F(3, 75) = 3.95; p < .05$
  - Main effect of position: $F(3, 75) = 19.40; p < .001$
  - Interaction: $F(9, 25) = 1.20; p = .29$

Interaction Plot

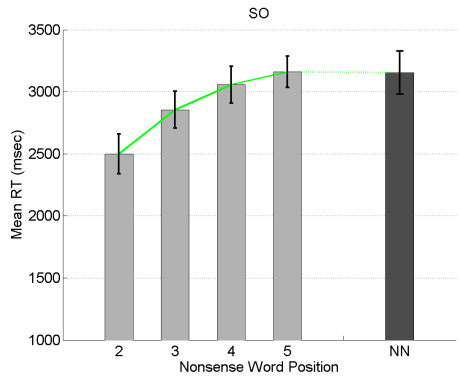


OO *The director humiliated$_2$ the actor$_3$ who the critic$_4$ impressed$_5$*
OS *The director humiliated$_2$ the actor$_3$ who impressed$_4$ the critic$_5$*
SO *The actor who the critic$_2$ impressed$_3$ humiliated$_4$ the director$_5$*
SS *The actor who impressed$_2$ the critic$_3$ humiliated$_4$ the director$_5$*

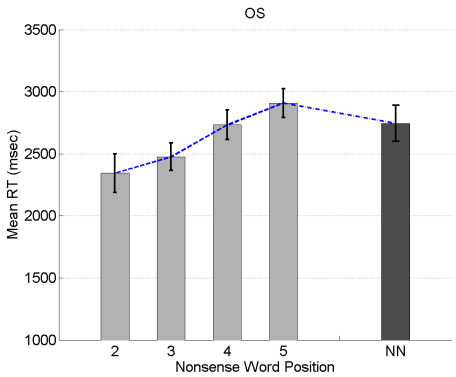
Split Apart



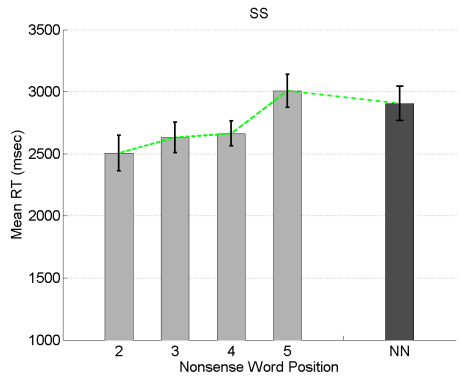
OO *The director humiliated$_2$ the actor$_3$ who the critic$_4$ impressed$_5$*



SO *The actor who the critic$_2$ impressed$_3$ humiliated$_4$ the director$_5$*

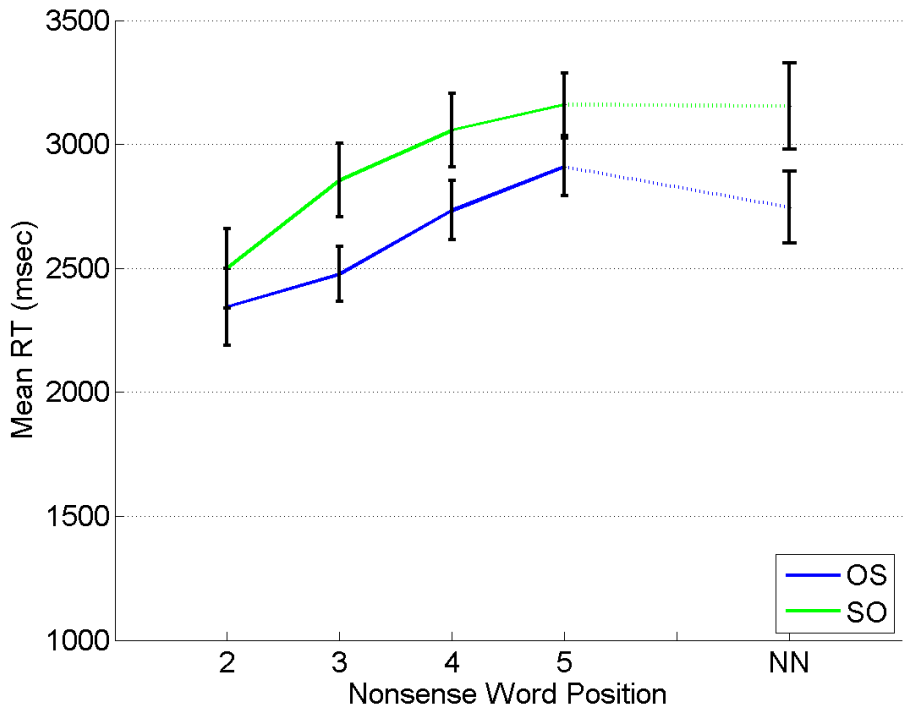


OS *The director humiliated$_2$ the actor$_3$ who impressed$_4$ the critic$_5$*



SS *The actor who impressed$_2$ the critic$_3$ humiliated$_4$ the director$_5$*

SO and OS



OS *The child*$_1$ *spilled*$_2$ *the juice*$_3$ *that stained*$_4$ *the rug*$_5$

SO *The juice*$_1$ *that the child*$_2$ *spilled*$_3$ *stained*$_4$ *the rug*$_5$

All Three Experiments

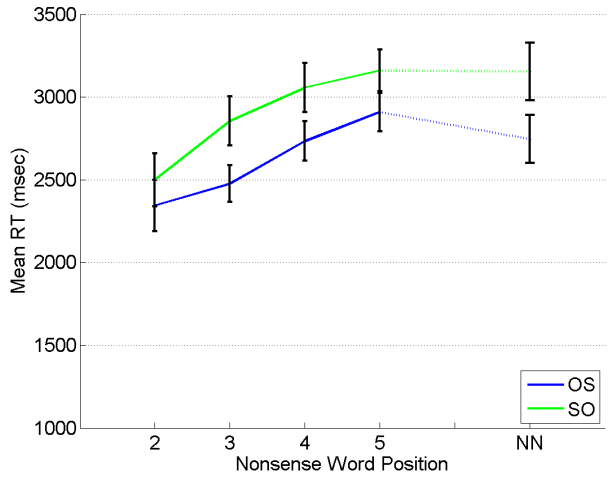


Figure 1: 2012

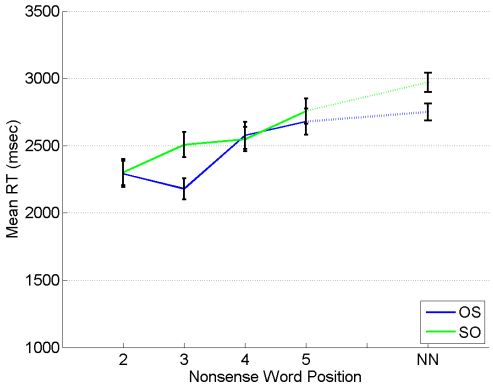


Figure 2: 1996

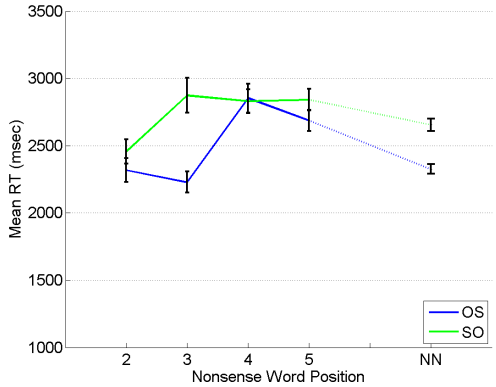


Figure 3: 2011

Discussion

- In all three experiments, participants "parsed" the sentences
  - . . . even though the task did not require it
- However, the "parsing" strategy seems to be different across:
  1. Experiments
  2. Nonsense word positions – specifically, "early" vs. "late"

Open Questions

- What differentiates "early" and "late"?
  - Does the strategy change after crossing a certain point?
  - What is that point?
- If parsing, are nonsense words integrated the same way as regular words?
  - Unfortunately, the whole sentence design does not allow us to get per-word costs
- Currently, we are using the self-paced reading design to evaluate whether parsing strategy changes after encountering nonsense words

Thank you

Filler Types

BY-VP-AC	The activist began the rebellion by organizing the strike.
BY-VP-PS	The actress was praised by the director filming the movie.
COM-AC	The babysitter grounded the child and called the parents.
COM-PS	The car was hit by the truck and towed by the mechanic.
OBJ-PP-AC	The crowd admired the vocalist of the band.
OBJ-PP-PS	The dog was mauled by the leopard from the zoo.
SBJ-PP-AC	The father of the bully insulted the teacher.
SBJ-PP-PS	The nurse in the hospital was scolded by the patient.
SIM-AC	The lighthouse guided the sailor.
SIM-PS	The wife was adored by the husband.