Distinguishing effects of number interference and number attraction in sentence processing

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1. Introduction

According to similarity based interference accounts (Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005) retrieval interference affects the integration of a verb with its dependents that are stored in memory. Retrieval of the dependents should be more difficult when they share retrieval cues, e.g. for number. Number information is also important for agreement processes: a verb's number marking (in present tense) needs to agree with its subject's number marking. Processing should be slower when an intervening noun phrase between the subject and the finite verb agrees with the verb than when it does not. Wagers, Lau, and Phillips (2009) have shown that an intervening noun phrase affects the comprehension difficulty that is associated with the processing of ungrammatical sentences.

2. Materials and Predictions Experiment 1

Experiment 1 with 2×2 design: **number of NP2** and **number of NP3**.

1. plural NP2 / plural NP3

The secretary who argued with the customers of the directors | was on | the train | to the meeting.

2. plural NP2 / singular NP3

The secretary who argued with the customers of the director | was on | the train | to the meeting.

3. singular NP2 / plural NP3

The secretary who argued with the customer of the directors | was on | the train | to the meeting.

4. singular NP2 / singular NP3

The secretary who argued with the customer of the director | was on | the train | to the meeting.

- Number interference account: longer reading times at *was on* when the number of the intervening NPs was the same as the subject *the secretary* than when it was different. (Van Dyke & Lewis, 2003)
- Number attraction account: integration of *was on* more difficult when number inflected verb is preceded by a NP with a different number (*cousins* or *farmers*) than when the inflected verb is preceded by a NP with the same number (*cousin* or *farmer*). (Wagers et al., 2009)

3. Eye-tracking Experiment 1

Forty non-dyslexic native speakers from the University of Dundee participated in the eye-tracking experiment. We tested forty critical sentences.

First fixation duration

legend: * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

Total reading time

First fixation duration: effect of number of NP3 ($F(1,36) = 4.17, p < .05$; $F(1,32) = 13.70, p < .01$) at *the train*. There were longer reading times at *the train* when NP3 was singular than when it was plural.

Total reading time: effect of the number of NP2 ($F(1,36) = 4.61, p < .05$; $F(1,32) = 6.00, p < .05$) at *the train*. There were longer reading times at *the train* when the NP2 was singular than when NP2 was plural.

4. Summary and intermediate discussion

To summarise, there were similarity based interference effects from NP3 in initial first fixation duration (*director(s)*) and from NP2 (*customer(s)*) in the later total reading times. There was no effect of number attraction in Experiment 1.

- No effect of number attraction in Experiment 1 might be because number attractor embedded in relative clause → syntactically more separated from verb.
- To test whether number attraction occurs from nouns not in a relative clause, Experiment 2 tested number attraction processes during ambiguity resolution.

5. Materials and Predictions Experiment 2

Experiment 2 with 2×2 design: **ambiguity** and **number of NP3**.

1. ambiguous / singular

After Virginia answered the cousin of the farmer | has to | think it | all over again.

2. ambiguous / plural

After Virginia answered the cousin of the farmers | has to | think it | all over again.

3. unambiguous / singular

After Virginia answered, the cousin of the farmers | has to | think it | all over again.

4. unambiguous / plural

After Virginia answered, the cousin of the farmer | has to | think it | all over again.

- number attraction predicts longer reading times after a plural NP3 (*farmers*)
- number interference predicts longer reading times a singular NP3 (*farmer*)

6. Eye-tracking Experiment 2

Forty non-dyslexic undergraduate students from the University of Dundee participated in this Experiment. Forty critical sentences were tested.

legend: * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

Regression-path time: effect of ambiguity at *has to* ($F(1,36) = 25.53, p < .001$; $F(1,36) = 43.35, p < .001$), at *think it* ($F(1,36) = 33.85, p < .001$; and $F(1,36) = 52.74, p < .001$.) and at *all over again* ($F(1,36) = 19.27, p < .001$; $F(1,36) = 32.26, p < .001$). Ambiguous conditions took longer to read in these regions.

Important: interaction between ambiguity × number of NP3 ($F(1,36) = 4.87, p < .05$; $F(1,36) = 5.03, p < .05$) at *has to*. Simple effects analysis showed ($F(1,36) = 5.26, p < .05$; $F(1,36) = 5.67, p < .05$) that ambiguous conditions had longer regression-path times for conditions with plural NP3 than for those with singular NP3. There was no difference between the unambiguous conditions.

Total reading time: effect of ambiguity at *has to* ($F(1,36) = 62.75, p < .001$; $F(1,36) = 80.99, p < .001$) and at *think it* ($F(1,36) = 27.79, p < .001$; $F(1,36) = 22.35, p < .001$). Ambiguous conditions had longer total reading times than unambiguous conditions.

7. Summary and intermediate discussion

Experiment 2 showed an effect of **ambiguity** in regression-path time (all critical regions) and total reading time (critical and spillover region). **Number attraction** affected the reading time of the ambiguous conditions in regression-path time at *has to*. There was no effect of number interference.

- Interaction in regression-path time showed that number attraction affected reanalysis processes.
- Thus number attraction might be part of checking processes that occur after initial structure building.
- There was no effect of number interference due to the short distance between the subject and the verb. As a result, the subject is highly activated even when a NP with the same number intervenes.

8. General Discussion

Experiment 1 showed effects of number interference. These effects occurred early in first-fixation duration and were short-lived since they didn't occur in any of the later measures like total reading times and regression-path times. When the number attractor was embedded and therefore more syntactically separated from the verb there was no effect of number attraction in Experiment 1.

Experiment 2 showed an effect of number attraction. The results of Experiment 2 suggest that number attraction affects reanalysis processes. Thus, number attraction can affect the comprehension of grammatical sentences as part of later checking processes that occur after initial structure building.

References

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