Lingering Misinterpretations in Garden-Path Sentences: Evidence From a Paraphrasing Task

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Using a forced-choice question-answering paradigm, K. Christianson, A. Hollingworth, J. F. Halliwell, and F. Ferreira (2001) showed that the original misinterpretation built during the analysis of a garden-path sentence lingers even after reanalysis has occurred. However, their methodology has been questioned (R. P. G. van Gompel, M. J. Pickering, J. Pearson, & G. Jacob, 2006). In this study, the authors report evidence for lingering misinterpretations using a paraphrasing methodology, which is less biased than previous methodologies. Using paraphrasing, they found that garden-path sentences are paraphrased according to a partially reanalyzed interpretation. This finding suggests that the arguments put forward by Christianson et al. are correct: Comprehenders' final interpretations of sentences are often incorrect and do not correspond to the initial input. These findings support the theory that comprehension can occur in a "good-enough" manner (F. Ferreira, V. Ferraro, & K. G. D. Bailey, 2002; F. Ferreira & N. Patson, 2007).

Keywords: sentence processing, lingering misinterpretations, garden-path recovery

One powerful tool used by psycholinguists has traditionally been the so-called garden-path sentence, such as Sentence 1 below.

> 1. While Anna bathed the baby spit up on the bed.

The structure of this sentence is temporarily ambiguous and has repeatedly been shown to cause difficulty during processing (e.g., Ferreira & Clifton, 1986; Ferreira & Henderson, 1991; Frazier & Rayner, 1982; Pickering & Traxler, 1998; Pickering, Traxler, & Crocker, 2000). However, until quite recently, researchers have ignored the content of the final interpretations that readers build for these sentences. It had been assumed that once the difficulty is encountered, the parser engages in some kind of reanalysis and builds the correct structure for the sentences; from this structure, the reader then derives the correct interpretation for the sentence. However, in a pioneering study, Christianson, Hollingworth, Halliwell, and Ferreira (2001) showed that the original direct object analysis of the temporarily ambiguous noun phrase (e.g., the baby)

built during the analysis of a garden-path sentence lingers even after reanalysis has taken place.

Christianson et al. (2001) asked participants to read subordinate–main garden-path sentences and then answer a forced-choice (yes/no) question like those below:

> 2. While the man hunted the deer ran through the woods.
>
> 2a. Did the man hunt the deer?
>
> 2b. Did the deer run through the woods?

They found that participants answered "yes" (incorrectly) to Question 2a close to 60% of the time. In addition, participants answered "yes" (correctly) to Question 2b nearly 90% of the time. Because the proportion of "yes" answers to Questions 2a and 2b summed to more than one, Christianson et al. argued that even when participants understood that the deer ran through the woods, they still believed (incorrectly) that the deer was the direct object of *hunted* (see also Davidson, Zacks, & Ferreira, 2003, for direct evidence that comprehenders maintained both propositions simultaneously). Christianson et al. argued that although the parser had gone back and correctly stolen *the baby* from the subordinate verb syntactic analysis and made it the subject of the main verb, it had not gone back and cleaned up the incorrect direct object relationship from the original syntactic tree it had built. They took this as evidence for *partial reanalysis*. That is, the parser begins the process of reanalysis, but once it has obtained a viable structure, it may not continue to reanalyze so that it arrives at the ultimately correct structure.

Despite the significance of the Christianson et al. (2001) findings, two concerns have been raised about the methodology used

in their experiments. The first is that the forced-choice response paradigm could have caused participants to reevaluate the sentences in a manner that led them to be more likely to accept the original misinterpretation. Second, the question may have affected the final representation of the sentence: Participants may not have had a final representation of the sentence before reading the question and, thus, the question may have primed the original interpretation (an argument made by van Gompel, Pickering, Pearson, & Jacob, 2006). However, two recent studies, which we describe below, have found effects of lingering misinterpretations without reintroducing the problematic structure (Kaschak & Glenberg, 2004; van Gompel et al., 2006).

Kaschak and Glenberg (2004) suggested that lingering misinterpretations are not due to partial reanalysis but rather memory traces from activating the inappropriate syntactic analysis. They used constructions such as that found in Sentence 3 below, which are not found in the dialects spoken by their participant sample but which are acceptable in varieties of English such as those spoken in parts of central Pennsylvania as well as in Scotland.

> 3. This meal needs cooked given that dinner is in an hour.

In the critical experiment, participants were either trained to learn the meanings of sentences like Sentence 3 or they were trained on a standard construction such as that found in Sentence 4, which acted as a control.

> 4. This meal needs to be cooked given that dinner is in an hour.

After being trained on either Sentence 3 or Sentence 4, participants engaged in the second half of the experiment in which they then read sentences with modifier constructions, such as Sentence 5, in a self-paced reading study.

> 5. This meal needs cooked vegetables to make it complete.

Kaschak and Glenberg (2004) found that participants who were trained with the novel construction in Sentence 3 read the modifier construction in Sentence 5 faster than did those who had been trained on the standard construction in Sentence 4. They argued that during training, participants in the novel construction had incorrectly built a modifier construction before reanalyzing and obtaining the correct interpretation of the sentence. The incorrect analysis, built during training, lingered, causing participants in that condition to read the modifier sentences faster than those participants who had not built the misanalysis. Although this methodology was successful in providing evidence that misinterpretations linger, it has limitations. The participants were reading an unfamiliar construction, which may have led them to develop strategies they would not have used during natural comprehension.

Recently, van Gompel et al. (2006) investigated the effects of lingering misinterpretations using a structural priming methodology. In a very clever set of experiments, they showed that the structure of the inappropriate analysis (transitive structure) can be primed. They found that participants were more likely to produce a transitive structure (e.g., "When the doctor was visiting the patient yesterday . . .") after reading a subordinate–main ambiguity like in Sentence 6a than after reading its disambiguated counterpart, Sentence 6b:

> 6a. While the man was visiting the children who were surprisingly pleasant and funny played outside.

> 6b. While the man was visiting, the children who were surprisingly pleasant and funny played outside.

They took these findings as evidence that participants had indeed built the transitive structure and that the transitive structure was still available when the participants began to produce a new sentence. However, although this priming study does not reintroduce the problematic structure, it also does not reveal the final interpretation of the original garden-path sentence. Thus, we are only able to infer that readers are holding on to the original misinterpretation, but we do not know whether they also constructed the correct analysis of the temporarily ambiguous noun phrase.

The findings from these studies suggest that after reading a temporarily ambiguous sentence, the inappropriate analysis lingers in some form, whether or not the sentence has been understood correctly (Christianson et al., 2001; Kaschak & Glenberg, 2004; van Gompel et al., 2006). Because both the Kaschak and Glenberg (2004) and the van Gompel et al. (2006) studies probed subsequent sentences (not the garden-path sentences themselves), neither methodology allows for the original sentence to be reevaluated. Furthermore, both studies avoided reintroducing the problematic interpretation. Despite these differences, both Kaschak and Glenberg and van Gompel et al. found evidence for lingering misinterpretations, confirming the original findings of Christianson et al. (2001). However, these two methodologies do not allow the final interpretation of the garden-path sentence to be analyzed, in contrast to the Christianson et al. methodology. Therefore, here we introduce a new methodology, paraphrasing, that allows the final interpretation of the garden-path sentence to be analyzed without explicitly reintroducing the problematic structure. This method provides new information about the nature of lingering misinterpretations.

Current Study

Although van Gompel et al. (2006) and Kaschak and Glenberg (2004) provided evidence that misinterpretations linger without reintroducing the problematic structure, they did not provide a direct measurement of comprehenders' final interpretation of temporarily ambiguous sentences. Our aim was to use a methodology for measuring comprehenders' final interpretations that does not involve repeating the garden-path structure with a question prompt. In our experiment, we asked participants to paraphrase the meaning of garden-path sentences. This methodology forces participants to derive a final interpretation of the sentences they read. In addition, it does not coerce participants into accepting the original misinterpretation by explicitly reintroducing the problematic structure, as they are essentially engaging in free recall.

In our experiment, we found that the original misinterpretations do indeed linger, as shown by participants' paraphrases of garden-path sentences. Nearly 70% of the time, participants produced a paraphrase that was consistent with a partially reanalyzed interpretation of the sentence. Our findings were fully consistent with those of Christianson et al. (2001) and suggest that the question-answering methodology is not biased in the way that has been suggested. Using the paraphrasing task, we are able to find direct

evidence for partial reanalysis. In contrast, with the question-answering methodology, evidence for partial reanalysis is indirect and must be inferred from the data.

Method

Participants

Fifty undergraduates from Michigan State University participated for partial course credit. All were native speakers of American English.

Materials

Twenty-four garden-path sentences were used in this study. All sentences were taken from Christianson et al. (2001). For a complete list of all the experimental stimuli, see the Appendix. Two types of verbs were used in the garden-path sentences: reflexive absolute transitive verbs and optionally transitive verbs. Two example sentences follow.

7. While Anna bathed the baby spit up on the bed. (Reflexive verb)

8. While the man hunted the deer ran through the woods. (Optionally transitive verb)

A detailed discussion of the differences between these two verb types can be found in Christianson et al. (2001). Here, we simply note that optionally transitive verbs follow the typical pattern for English, in that if the verb is used without an object, the interpretation is that the object is unspecified (e.g., "while the man hunted" means that the man hunted an unspecified object). In contrast, for reflexive verbs, the intransitive form has a reflexive interpretation; for example, "while Mary bathed" means that Mary bathed herself. The main reason for including both verb classes was to increase the number of stimulus items. We also chose to use the same stimuli as Christianson et al. so we could directly compare our results with theirs.

For each participant, half of the stimuli were presented with a disambiguating comma and half were not. Two lists were created so that each item was presented in both the disambiguated and the ambiguous conditions but so that no one participant saw the same item twice. In addition, 72 filler stimuli were created. Thus, participants read and paraphrased a total of 96 sentences. Fillers consisted of a variety of syntactic constructions and about half contained two clauses. In addition, 25 of the fillers contained a comma that did not mark the boundary of a clause.

Apparatus

Stimuli were displayed at a resolution of 800×600 pixels with 24-bit color on a 19-in. Dell P991 monitor driven by a NVIDIA GeForce3 video graphics card with a screen refresh rate of 100 Hz. Overhead fluorescent lighting illuminated the room.

Stimulus presentation and response collection were controlled by E-Prime experimental software. Responses were recorded via keypress. The display monitor was interfaced with a 2-GHz Pentium 4 microcomputer. The computer controlled the experiment and maintained a complete record of the time values for keypresses over the course of each trial.

Design

This study was run as a 2×2 within-subjects design. The first variable was verb type, either reflexive or optionally transitive, and the second variable was ambiguity, either ambiguous or disambiguated.

Procedure

On arrival at the laboratory, participants were greeted and given instructions for the experiment. After providing their consent, participants began the experiment. Each trial began with a fixation cross at the left-hand side of the computer screen. After 1,000 ms, the fixation cross disappeared and was replaced with a sentence. Participants were instructed to read the sentence and press the space bar when they were finished without rereading the sentence. When they pressed the space bar, the sentence disappeared and a text box appeared that instructed participants to paraphrase the meaning of the sentence they had just read by typing the paraphrase into the text box. They were told not to simply repeat the sentence and were encouraged to try to use synonyms for some of the words in the original sentence. They were given examples of unacceptable paraphrases, which included paraphrases that were reiterations of the original sentence and paraphrases that deleted major portions (e.g., verb phrases) of the original sentence.

Scoring

Paraphrase responses were coded into four categories: failed reanalysis, partial reanalysis, full reanalysis, and other (see Table 1). *Failed reanalysis* meant participants responded with only the initial misinterpretation and ignored the main clause. *Partial reanalysis* indicated that the participants made the temporarily ambiguous noun phrase the direct object of the subordinate clause verb and the subject of the main clause. *Full reanalysis* indicated that the participants made the temporarily ambiguous noun phrase the subject of the main clause and successfully unattached the temporarily ambiguous noun phrase from the subordinate verb. Paraphrases were coded *other* when participants failed to recall the original sentence and therefore could not come up with a paraphrase. Additionally, responses were coded *other* when participants' paraphrases were ambiguous because they either repeated the garden-path construction or used an ambiguous pronoun (e.g., "Anna bathed the baby and she spit up on the bed"). Paraphrases coded *other* accounted for only 4% of the data. For each participant, mean proportions of no response, failed, partial reanalysis, full reanalysis, and other were calculated for each verb type.

Table 1

Example Paraphrases by Category for the Target Sentence "While Anna bathed the baby spit up on the bed."

Category	Example paraphrase
Failed reanalysis	Anna bathed the baby.
Partial reanalysis	Anna bathed the baby and it spit up on the bed.
Full reanalysis	The baby spit up on the bed while Anna took a bath.

Paraphrases were coded first by two research assistants who were blind to the purposes of the study. The research assistants were provided with a number of examples of possible paraphrases of garden-path sentences not included in this study. Along with each paraphrase, the research assistants were told what score the paraphrase should obtain and given a justification for each of the ratings. During coding, both research assistants were blind to the condition that the sentence to be paraphrased appeared in. Interrater reliability was high, $\kappa = 0.90$. All differences were resolved by discussion, and if a unanimous score could not be reached, the paraphrase was scored as *other*. Ultimately, there were very few disagreements as participants' paraphrases could easily be categorized into one of our four groups.

Results

A 2×2 analysis of variance (using both subjects and items as random factors) was conducted using proportion of paraphrase categories as the dependent measure. (Note that although we have analyzed the paraphrase categories separately, the proportions are not independent.) The independent factors were Ambiguity Type $\times$ Verb Type. Mean proportions for each category by ambiguity and verb type are shown in Table 2.

For the proportion of paraphrases categorized as failed reanalysis, there were no effects of the experimental manipulations, all $ps > .05$. Because both the failed reanalysis category and the other category had few responses and the responses did not differ across conditions, the results for the partial reanalysis category were essentially the complement of those for the full reanalysis category.

For the proportion of paraphrases categorized as partial reanalysis, there was a main effect of ambiguity, $F_1(1, 49) = 140.98$, $MSE = 0.066$, $p < .01$, and $F_2(1, 23) = 62.23$, $MSE = 0.038$, $p < .01$. Paraphrases were more likely to be categorized as consistent with partial reanalysis if the original sentence appeared in the ambiguous condition ($M = .72$) than if it appeared in the disambiguated condition ($M = .29$). There was also a main effect of verb type that was significant only by subjects, $F_1(1, 49) = 6.82$, $MSE = .033$, $p < .05$, and $F_2(1, 23) = 2.98$, ns, such that paraphrases were more likely to be categorized as partial reanalysis if the verb was optionally transitive than if the verb was reflexive. This main effect was qualified by a significant interaction between ambiguity and verb type, $F_1(1, 49) = 23.70$, $MSE =$

0.03, $p < .01$, and $F_2(1, 23) = 23.46$, $MSE = 0.009$, $p < .01$. Paraphrases were more likely to be categorized as partial reanalysis in the disambiguated condition if the verb was optionally transitive than if the verb was reflexive, $t_1(49) = 4.73$, $p < .01$, and $t_2(11) = 3.89$, $p < .01$. However, in the ambiguous condition, there was no difference between the two verb types, $p > .05$.

For the proportion of paraphrases categorized as full reanalysis, there was a main effect of ambiguity, $F_1(1, 49) = 112.36$, $MSE = 0.074$, $p < .01$, and $F_2(1, 23) = 69.96$, $MSE = 0.031$, $p < .01$. Paraphrases were more likely to be categorized as full reanalysis if the original sentence appeared in the disambiguated condition ($M = .62$) than if it appeared in the ambiguous condition ($M = .21$). There was also a main effect of verb type that was only significant by subjects, $F_1(1, 49) = 7.76$, $MSE = 0.032$, $p < .01$, and $F_2(1, 23) = 3.04$, ns, such that paraphrases were more likely to be categorized as full reanalysis if the verb was reflexive than if it was optionally transitive. This main effect was qualified by a significant interaction, $F_1(1, 49) = 24.41$, $MSE = 0.025$, $p < .01$, and $F_2(1, 23) = 11.52$, $MSE = 0.014$, $p < .01$. Paraphrases were more likely to be categorized as full reanalysis in the disambiguated condition if the verb was reflexive than if it was optionally transitive, $t_1(49) = 4.59$, $p < .01$, and $t_1(11) = 0.99$, $p < .05$. There was no difference between verb types in the ambiguous condition, $p > .05$.

Finally, for the proportion of paraphrases categorized as other, there were no effects of the experimental manipulations, all $ps > .05$.

Discussion

The results of our study indicate that during the comprehension of temporarily ambiguous sentences, the original misinterpretation remains in memory and influences the final interpretation of the sentence. This is fully consistent with the results reported by Christianson et al. (2001). Participants did paraphrase garden-path sentences to indicate they had derived a partially reanalyzed interpretation of the sentences. Furthermore, participants were more likely to produce these partially reanalyzed paraphrases when they had read the garden-path sentences than if they had read the same sentence with a disambiguating comma between the subordinate and main clauses. These results suggest that the results of Christianson et al. were not fully due to a biased methodology and that the question-answering methodology does not seem to be biased in the ways that other researchers have suggested. The final interpretation of garden-path sentences derived by comprehenders is often incorrect and corresponds to a partially reanalyzed interpretation of the sentence.

We found an interaction between verb type and ambiguity condition driving both partial and full reanalysis. In the ambiguous condition, there was no difference between the two verb types for proportion of partial reanalysis paraphrases. This finding suggests that when comprehenders temporarily build an interpretation in which the postverbal noun phrase is an object, they tend not to relinquish that interpretation, even when they have engaged in some type of reanalysis as evidenced by their understanding that the same postverbal noun phrase is the subject of the main clause verb. Because this effect is so strong, it washes out any difference in verb type.

Table 2
Means and Standard Deviations for Proportion of Paraphrase Category by Ambiguity

Ambiguity	Failed		Partial		Full		Other	
	M	SD	M	SD	M	SD	M	SD
Ambiguous								
OT verb	.04	.11	.69	.28	.23	.27	.03	.09
RAT verb	.02	.09	.74	.25	.19	.26	.04	.09
Disambiguated								
OT verb	.05	.11	.38	.25	.53	.31	.04	.15
RAT verb	.04	.09	.19	.19	.71	.27	.06	.13

Note. OT = optionally transitive verbs; RAT = reflexive absolute transitive verbs.

In contrast, in the disambiguated condition, there was a large difference between the two verbs—specifically, there were more partial reanalysis paraphrases for optionally transitive verbs than for reflexive verbs. With the commas present, there is no structural reason to build the object interpretation of the postverbal noun phrase. Thus, categorizing the paraphrases as partial reanalysis is a bit of a misnomer, as no actual reanalysis takes place. Instead, the difference is due to intrinsic differences between the two types of verbs. The two verb types were optionally transitive and reflexive. As we mentioned, these two verb types are critically different in how they are understood when they are interpreted intransitively. In the intransitive form, optionally transitive verbs have an unspecified object reading. That is, *Bill hunted* means that Bill hunted something, but what he hunted is left unspecified. However, reflexive verbs are different. In the intransitive form, *Anna bathed* means that Anna bathed herself; thus, the intransitive form has a specified interpretation. Therefore, we see an increased likelihood of partial reanalysis responses in the disambiguated condition with optionally transitive verbs because when comprehenders read "While Bill hunted, the deer ran through the woods," they are comfortable with the idea that Bill hunted the deer, as that concept is consistent with the proposition that Bill hunted something, and it does not require them to leave anything unspecified. However, for reflexive verbs in sentences such as "While Anna bathed, the baby spit up on the bed," the proposition that Anna bathed the baby is inconsistent with the proposition that she bathed herself. Therefore, readers tend not to include it in their paraphrase.

The purpose of this study was to introduce the paraphrasing paradigm as a method for probing the final interpretation of temporarily ambiguous sentences. This methodology is useful because it allows the final interpretation, not an intermediate stage of interpretation, to be probed. Additionally, it does not suffer from some of the shortcomings previous methodologies have. First, unlike the question-answering paradigm (Christianson et al., 2001), it does not explicitly reintroduce the original misinterpretation, as participants are essentially engaging in free recall. However, as we have shown, it does not appear that reintroducing the problematic interpretation is necessarily cause for concern. Our results are fully consistent with the results previously reported by Christianson et al. (2001). Second, we did not have to use unfamiliar structures (Kaschak & Glenberg, 2004), which may lead to unnatural strategies during comprehension. Finally, unlike both the methodologies used by Kaschak and Glenberg (2004) and van Gompel et al. (2006), the paraphrasing paradigm allows the final interpretation of the sentence to be probed. Furthermore, it is the

only methodology that provides direct evidence that both interpretations are indeed held at once. In the question-answering methodology, this has to be inferred from the data patterns.

Using the paraphrasing methodology introduced in this article, we found evidence that comprehenders' final interpretation of a garden-path sentence is often wrong, in that it does not correspond to the correct syntactic analysis of the sentence. Instead, as other researchers have pointed out, the incorrect analysis often lingers and influences the final interpretation of the sentence. Our findings were consistent with Christianson et al.'s (2001) suggestion that reanalysis is often only partially completed. These data provide do not provide evidence that the final interpretation comprehenders derive of a sentence is not always a sum of its parts; rather, the data support the conclusion that comprehension can occur in a good-enough manner (Ferreira, Ferraro, & Bailey, 2002; Ferreira & Patson, 2007).

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Appendix
Stimuli Used in the Paraphrasing Task

Items 1–12 contain optionally transitive verbs, and Items 13–24 contain reflexive verbs.

1. While the man hunted(,) the deer that was brown and graceful ran into the woods.

2. While the skipper sailed(,) the boat that was small and leaky veered off course.

3. While the reporter photographed(,) the rocket that was silver and white sat on the launch pad.

4. While the orchestra performed(,) the symphony that was short and simple played on the radio.

5. While the student read(,) the notes that were long and boring blew off the desk.

6. While Jack ordered(,) the fish that was silver and black cooked in a pot.

7. While Susan wrote(,) the letter that was long and eloquent fell off the table.

8. While the secretary typed(,) the memo that was clear and concise neared completion.

9. While the farmer steered(,) the tractor that was big and green pulled the plough.

10. While the lawyer studied(,) the contract that was old and wrinkled lay on the roll-top desk.

11. As Henry whittled(,) the stick that was long and bumpy broke in half.

12. While Rick drove(,) the car that was red and dusty veered into a ditch.

13. While Jim bathed(,) the child that was blond and pudgy giggled with delight.

14. While the chimps groomed(,) the baboons that were large and hairy sat in the grass.

15. While Frank dried off(,) the car that was red and shiny sat in the driveway.

16. While Betty woke up(,) the neighbor that was old and cranky coughed loudly.

17. While the thief hid(,) the jewelry that was elegant and expensive sparkled brightly.

18. While Anna dressed(,) the baby that was small and cute spit up on the bed.

19. While the boy washed(,) the dog that was white and furry barked loudly.

20. While the jockey settled down(,) the horse that was sleek and brown stood in the stall.

21. While the mother undressed(,) the baby that was bald and helpless cried softly.

22. While the nurse shaved(,) the patient that was tired and weak watched TV.

23. While the girl scratched(,) the cat that was grey and white stared at the dog.

24. While the mother calmed down(,) the children that were tired and irritable sat on the bed.