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Thematic Roles Assigned along the Garden Path Linger

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In the literature dealing with the reanalysis of garden path sentences such as *While the man hunted the deer ran into the woods,* it is generally assumed either that people completely repair their initial incorrect syntactic representations to yield a final interpretation whose syntactic structure is fully consistent with the input string or that the parse fails. In a series of five experiments, we explored the possibility that partial reanalyses take place. Specifically, we examined the conditions under which part of the initial incorrect analysis persists at the same time that part of the correct final analysis is constructed. In Experiments 1a and 1b, we found that both the length of the ambiguous region and the plausibility of the ultimate interpretation affected the likelihood that such sentences would be fully reanalyzed. In Experiment 2, we compared garden path sentences with non-garden path sentences and compared performance on two different types of comprehension questions. In Experiments 3a and 3b, we constructed garden path sentences using a small class of syntactically unique verbs to provide converging evidence against the position that people employ some sort of ''general reasoning'' or pragmatic inference when faced with syntactically difficult garden paths. The results from these experiments indicate that reanalysis of such sentences is not always complete, so that comprehenders often derive an interpretation for the full sentence in which part of the initial misanalysis persists. We conclude that the goal of language processing is not always to create an idealized structure, but rather to create a representation that is ''good enough'' to satisfy the comprehender that an appropriate interpretation has been obtained.

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In order to derive meaning from a sentence, the language comprehension system must divide a visual or aural input string into constituents such as words, intonational phrases, and syntactic units (phrases and clauses). A central assumption in the study of language comprehension has been that sentence meaning is derived from a complete representation built up from the component parts of an utterance into a fully specified syntactic structure. In this article, we challenge this assumption by providing evidence that, under certain conditions, participants form confident interpretations for sentences of English despite the fact that a coherent, syntactically licensed structure was either not produced faithfully from the input string or not produced at all. Specifically, the experiments reported in this article demonstrate that when people read a sentence such as *While Anna dressed the baby spit up on the bed* they often end up confidently believing that Anna dressed the baby, even though that proposition is not compatible with the sentence's true content.

This assertion may appear counterintuitive since our conscious impression is that sentence comprehension normally proceeds smoothly. However, as readers and listeners, we quite frequently encounter sentences that are ambiguous or downright confusing, as in example (1) (taken from Atkinson, 1995, p. 11):

(1) *At the moment at which I moved from nothingness into being my mother was pretending to be asleep—as she often does at such moments*

This sentence is from the 1996 Whitbread Book of the Year, *Behind the Scenes at the Museum,* and is an example of a *garden path sentence*. Descriptively, garden path sentences result in some sort of misanalysis in the initial syntactic analysis or parse. When the misanalysis is recognized by the parser (typically due to the breakdown in the ongoing analysis), reanalysis is required. The reader (or listener) may even be conscious of the effort required to perform reanalysis in the case of difficult garden path sentences. It is precisely these misanalyses, or breakdowns in parsing, that make garden path sentences a fertile area of study. By investigating how garden path sentences are initially parsed, reanalyzed, and ultimately comprehended, we can gain insight into the underlying mechanisms that usually operate accurately.

An example of the type of difficult garden path sentence used in the experiments described below is seen in sentence (2). The noun phrase (NP) *the deer* is initially attached to the syntactic representation of the sentence as the object of the verb *hunted,* when ultimately it must serve instead as the subject of the matrix clause verb *ran* and the subordinate verb *hunted* must in fact be intransitive.

(2) *While the man hunted the deer ran into the woods.*

The *garden path model* of sentence comprehension (Frazier & Fodor, 1978; Frazier & Rayner, 1982) provides an account of how *the deer* is initially attached. The principle of Late Closure holds that, when allowed by

the syntax, incoming material is attached inside the clause or phrase currently being processed. This principle, then, prohibits *the deer* from being attached outside the subordinate clause because to do so would result in the *early closure* of the clause, i.e., closing off the subordinate verb's argument structure despite the presence of an apparently compatible object in the input string. After the attachment of *the deer* as object of *hunted,* the verb *ran* signals an error in the initial parse because English requires that verbs have an overt subject. In order to reach a syntactically licensed interpretation in (2), the NP *the deer,* initially parsed as the direct object and theme of the subordinate verb *hunted,* must be recruited instead as the subject and agent of the matrix verb *ran*. To borrow from the terminology of Fodor and Inoue (1998), the portion of the input string *the deer* is ''stolen'' from the subordinate clause. Crucially, the subordinate verb must also be reanalyzed as intransitive such that *the deer* is no longer structurally attached or thematically related to the verb *hunted*. Fodor and Inoue propose that a process which they call ''Adjust'' performs this tidying up of the syntactic structure. The locus of interpretation under this model is purely syntactic, with misinterpretation stemming from syntactic misanalysis. It is important to note, however, that virtually all models of sentence comprehension predict this misanalysis and propose some mechanism by which the ultimately correct parse can be achieved. For example, according to constraint-based accounts (MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Kello, 1993), the phrase *the deer* is initially treated as the object of *hunted* because the verb *hunt* may be more frequently transitive than intransitive and the sentence lacks a comma. Thus, several sources of information point to the transitive analysis, which then must be undone when the error signal from *ran* is encountered.

Most researchers hold that the reanalysis of garden path sentences is an all-or-nothing proposition: these sentences are either successfully reanalyzed or not. If reanalysis is successful, then all the steps described above are completed and an interpretation of the sentence licensed by the syntax and consistent with the input string is produced. If not, a sentence-level interpretation cannot be derived, or at least cannot be derived systematically, consistently, and confidently. Consider the following quote from Frazier and Clifton (1996): ''We take it to be crucial that, barring errors, readers and listeners do not violate their knowledge of grammar in arriving at an interpretation of a sentence'' (Frazier & Clifton, p. 3). MacDonald et al. (1994) argue that there might be situations in which ''the communicative goals of the listener can be achieved with only a partial analysis of a sentence, but we view these as degenerate cases'' (p. 686). Thus, if a sentence is an ''easy'' garden path, the assumption is that people fully reanalyze the sentence. If a sentence is a ''difficult'' garden path, it is generally assumed that, although some sort of initial parsing mistake is recognized, recovery is hampered or prevented due either to syntactic limitations on reanalysis or to activation levels of

alternate structures falling close to zero. When subjects either judge a garden path sentence as ungrammatical or require an extremely long time to process the garden path, it is widely accepted that no global interpretation can be reached beyond, perhaps, a vague general inference (i.e., a guess) based on an informal combination of word and/or phrase meaning and one's knowledge of the world.

The possibility exists, however, that even in cases in which reanalysis is not completely successful people may nonetheless systematically obtain sentence-level interpretations. In (2), the comprehender can be confident that a man is hunting and that something is running into the woods. The interesting question, then, is whether the comprehender clings to the interpretation that the man is hunting the deer mentioned in the sentence. If he or she properly executes the full set of reanalysis procedures described above, then the answer is no: The comprehender will take the subordinate clause to mean that the man is hunting some unspecified quarry. But if the repair is just ''good enough'' (Ferreira & Henderson, 1999) to take care only of the syntactic problem caused by the initial parse, and, crucially, not ''good enough'' to tidy up the other parts of the representation, then the comprehender might simultaneously maintain both the interpretation based on the correct, revised latter portion of the structure and the meaning created from the initial, incorrect parse of the earlier portion. The question we address in this article is the following: To what extent and under what conditions does the full syntactic—and consequently the semantic—repair take place?

The experiments presented here take advantage of garden path effects and other syntactic and nonsyntactic manipulations to examine the extent to which reanalysis takes place. However, we are not simply offering further evidence of inferential processes in support of the old observation that such processes can intrude upon both sentence recall and discourse comprehension (e.g., Bransford & Franks, 1971; Bransford & Johnson, 1972, 1973). Rather, we aim to pinpoint a very specific semantic consequence of a syntactic misanalysis. Furthermore, we demonstrate that the effects of this misanalysis persist throughout the duration of the subsequent analysis and reanalysis and can be detected independently of inferential effects. Of course, sentence (2) is compatible with the notion that the man is hunting a deer: If a man is hunting and a deer is mentioned in that context, it is not unreasonable to infer that the man is hunting the deer. We view this tendency to infer that the man might be hunting the deer in the absence of a syntactic analysis in which *the deer* actually occurs as the grammatical object of *hunting* as indicating the extent to which the comprehender draws a pragmatic inference. We assume that this tendency exists—that is, that when our participants say that yes, the man is hunting the deer, they are basing that judgment in part on this pragmatic inference. The crucial manipulations in this study all involve placing the information in the sentence in such a way that a syntactic structure is created in which *the deer* is temporarily the object of *hunted* in order

to measure the tendency that exists over and above the pragmatic inference. If we find that comprehenders' inclination to say that the man is hunting the deer is greater in garden-pathing conditions compared to those in which a garden path does not occur, and if we find further that the severity of the garden path correlates with the likelihood of the deer-hunting belief, then we have evidence that the belief is based not just on the pragmatic inference, but also on having temporarily entertained a syntactic structure which included *the deer* as an object of the verb, without having engaged in complete reanalysis of that structure.

In this study, then, we explored the interpretation, and misinterpretation, of garden path sentences. The general method was to present a garden path sentence such as (2) followed by a question probing the interpretation of that sentence, such as *Did the man hunt the deer?* (Experiments 1–3) or *Did the deer run into the woods?* (Experiment 2). In addition, we manipulated a number of properties of garden path and non-garden path sentences to determine which factors facilitated full reanalysis resulting in syntactically licensed interpretations of specific problematic constituent phrases and which blocked or partially blocked such interpretations. To preview the results, we found that initial thematic role assignments were surprisingly resistant to revision, and this resistance was reflected in participants' interpretations of the sentences. Interpretations based on the initial, incorrect parse were quite persistent and confidently held, even though such interpretations reflected only partial reanalysis and depended on globally unlicensed syntactic structures. The extent to which initial interpretations persevered was influenced by syntactic factors that created, exaggerated, or eliminated the garden path. These included ambiguous region length (Experiments 1a and 1b), head position within the ambiguous phrase (Experiments 2 and 3), clause order (Experiments 2 and 3a), comma use (Experiment 3b), and verb argument structure (Experiments 3a and 3b). We also demonstrate that a nonsyntactic factor, plausibility, caused initial interpretations to be retained (Experiments 1a and 1b). We discuss alternative accounts of the misanalysis and resultant misinterpretation of garden path sentences as well as elaborate on the concept mentioned above of ''good enough'' representations, both as it relates to the reanalysis of such sentences and as it relates to previous findings in psycholinguistics and cognitive science in general, under General Discussion.

EXPERIMENTS 1a AND 1b

In Experiments 1a and 1b we sought to test whether participants derive consistent interpretations from relatively difficult garden path sentences such as (2) and, if so, whether these interpretations reflect full or only partial reanalysis. In particular, we were interested in whether interpretations derived from initial, incorrect thematic role assignments would persevere due to difficult reanalysis. Sentences such as (2) were presented, and each was

followed by a question probing interpretation of the subordinate clause (*Did the man hunt the deer?* in this example). Participants were then asked to rate their confidence in the yes/no response. An interpretation based simply on a full syntactic reanalysis, in which *the deer* is recruited exclusively as subject and agent of the matrix clause, yields a ''no'' response. A ''yes'' response, and in particular a confidently held ''yes'' response, would signal an incomplete reanalysis, whereby *the deer* persists in some manner as the grammatical object and semantic Theme of the subordinate clause verb.

The garden path sentences were contrasted with a non-garden path control condition in which the NP *the deer* could not be interpreted as object of *hunted* at all (*While the man hunted the pheasant the deer ran into the woods*). If the resistance of thematic role assignments to revision leads to syntactically unlicensed interpretations when initial assignments are incorrect, then we should expect more ''yes'' responses to the question *Did the man hunt the deer?* in the garden path condition compared to the non-garden path control. Table 1 provides examples of each of the experimental conditions for one sentence item.

Because previous research has demonstrated that properties of a misanalyzed phrase influence ease of reanalysis (Ferreira & Henderson, 1991, 1998; Frazier & Clifton, 1998), we also included a manipulation of ambiguous region length. Ferreira and Henderson (1991, 1998) showed that the longer one is committed to (ultimately) incorrect thematic assignments, the more difficult full reanalysis is. Thus, if ''yes'' responses reflect an interpretation

TABLE 1
Sample Item in Experiments 1a and 1b

Sentence	
Garden path	
Plausible, short ambiguous region	
	While Bill hunted the deer ran into the woods.
Plausible, long ambiguous region	
	While Bill hunted the deer that was brown and graceful ran into the woods.
Implausible, short ambiguous region	
	While Bill hunted the deer paced in the zoo.
Implausible, long ambiguous region	
	While Bill hunted the deer that was brown and graceful paced in the zoo.
Non-garden path	
Plausible, short ambiguous region	
	While Bill hunted the pheasant the deer ran into the woods.
Plausible, long ambiguous region	
	While Bill hunted the pheasant the deer that was brown and graceful ran into the woods.
Question	
Did Bill hunt the deer?	

based on the perseverance of the initial thematic assignments, the proportion of incorrect ''yes'' responses should be higher when the ambiguous region is longer. In addition, the length of the ambiguous region should have a greater effect on responses to garden path compared to non-garden path sentences because in the former, the longer region should reduce the chances that full revision will occur (as implied by Ferreira and Henderson, 1991), whereas in the latter, a longer region should not influence thematic role revision. Thus, the manipulation of ambiguous region length allows us to measure the extent to which comprehenders' tendency to think *the man is hunting the deer* is due to syntactic misanalysis in addition to general inference.

Finally, we investigated how the pragmatic plausibility of the initial misinterpretation might influence the ultimate comprehension of the garden path sentences (Abney, 1988; Crain & Steedman, 1985; De Vincenzi & Job, 1993; Ferreira & Clifton, 1986; Frazier, 1978; Pickering & Traxler, 1998; Rayner, Garrod, & Perfetti, 1992; Spivey-Knowlton & Sedivy, 1995; Stowe, 1989). Sentences were written so that (for example) *the deer* was either *running into the woods* or *pacing in the zoo* (see Table 1). In the latter case, it is much less likely that the man is hunting the deer. If the plausibility of the interpretation that comes from the initial thematic role assignments can influence the extent to which syntactic reanalysis takes place, we expected to obtain fewer incorrect ''yes'' responses to the question ''Is the man hunting the deer?'' when that interpretation is implausible (i.e., when the deer is pacing in the zoo) compared to when that interpretation is plausible (i.e., when the deer is running into the woods).

In Experiment 1a, sentences were presented word by word in rapid serial visual presentation (RSVP) mode. To address the potential concern that participants might have difficulty remembering the sentence over the time course of a word-by-word presentation, we conducted Experiment 1b. In Experiment 1b, sentences were presented in full, and participants read each sentence at their own pace. The self-paced, full-sentence method of presentation was employed for all subsequent experiments.

Method

Participants. Thirty-six Michigan State University undergraduate students participated in Experiment 1a, and 36 different students participated in Experiment 1b, all for course credit. All participants were native speakers of English and were naïve with respect to the hypotheses under investigation.

Materials. Each sentence item appeared in one of six conditions. These conditions are illustrated in Table 1. Control sentences differed from garden path sentences by the addition of an extra NP (*the pheasant* in the example shown in Table 1). Within the garden path sentences, four conditions were created by the factorial combination of two variables: The ambiguous region was either short (*the deer*) or long (*the deer that was brown and graceful*) and the (syntactically incorrect) interpretation of this ambiguous NP as object of the matrix verb was either plausible (the hunted deer ran into the woods) or implausible (the hunted deer paced

in the zoo). Two non-garden path conditions were included that differed in the length of ambiguous region only. The plausibility of the initial misinterpretation was not varied, since these sentences provide an alternative object for *hunted*. The same question was presented for all six versions of a sentence item.

A set of 42 different sentence items was created. These are listed in Appendix 1. Each participant saw only one version of each sentence item but saw an equivalent number of items in each condition. Across participants, each sentence item appeared in each condition an equal number of times. The experimental items were presented along with 92 filler sentences. Due to the fact that all of the 42 experimental sentences required a ''no'' response, 42 of the fillers employed the same clause order (subordinate-matrix) but required a ''yes'' response. Half of these 42 asked a question about the verb of the matrix clause and half about the verb of the subordinate clause. The remaining 50 fillers had the reverse clause order (matrix-subordinate). Half required a ''yes'' response and the other half a ''no'' response. In each of these halves, half of the sentences asked a question about the verb of the matrix clause and half asked a question about the verb of the subordinate clause. None of the filler sentences was syntactically ambiguous.

Apparatus. The stimuli were displayed on a NEC XE15 (Multisync) monitor. Participants used a button box to start each trial, record their yes/no response, and record their confidence rating. Stimulus presentation and response collection was controlled by 486-66 microcomputer.

Procedure. Upon arriving for the experimental session, participants were given a written description of the experiment along with a set of instructions. The description informed participants that they would see sentences presented on a computer, answer a question about each sentence, and then rate their confidence in the response. Participants were seated at a computer monitor with a four-button response box placed on the table in front of them. At the beginning of each trial, a message appeared asking the participant to press a button to initiate the trial. After the participant pressed the button, a fixation box appeared in the center of the screen for 500 ms.

In Experiment 1a, the first word of the sentence replaced the fixation box, and this word was replaced by the second word, and so on, until the entire sentence had been presented. Each word was presented for a duration of 150 ms plus 20 ms per character in the word (see Gernsbacher & Hargreaves, 1988). In Experiment 1b, the full sentence replaced the fixation box on the screen, and participants pressed a button to continue to the question when they had finished reading the sentence. Participants were instructed to read each sentence at a normal pace and to press the button to proceed to the question without rereading the sentence.

After the sentence had been presented, there was another delay of 500 ms before the question appeared, in full, on the screen. The question remained on the screen until the participant pressed one button to respond ''yes'' or another button to respond ''no.'' Participants were given no specific instructions about how to respond to the question other than to respond either ''yes'' or ''no.'' After response, the words ''rate confidence'' appeared on the screen. These words remained on the screen until the participant pressed one of four buttons labeled ''1'' through ''4.'' A response of 1 corresponded to *highly confident* and 4 corresponded to *not at all confident*, with responses of 2 and 3 providing intermediate ratings between these two anchors. For ease of analysis and exposition, however, we converted these confidence ratings after each experiment so that 1 corresponded to lowest confidence and 4 to highest confidence. All reported confidence data reflect the converted ratings. After the confidence response, there was a short delay before the ''press button'' message appeared to begin the next trial.

Following review of the instructions, the participants took part in 10 practice trials: one sentence in each of the six experimental conditions and four filler sentences. The practice sentences were not included in the experimental session. The participants then saw all 134 sentences in the experimental session. The order of sentence presentation (and hence condition presentation) was determined randomly for each participant. The entire experiment lasted approximately 35 min.

Experiment 1a Results

The following data were collected for each trial: response (''yes'' or ''no''), confidence in response (1, 2, 3, or 4), and time taken to read and respond to the question.

Percentage ''yes'' responses. The percentage of incorrect ''yes'' responses in each condition is shown in Table 2. We first examined the garden path sentences. These data were analyzed as a 2 × 2 factorial (ambiguous region length × plausibility). In this and in subsequent analyses, two analyses of variance (ANOVAs) were conducted, one treating participants as a random effect ($F1$) and one treating sentence item as a random effect ($F2$). Reported means were derived from analyses treating participants as a random effect. There was a main effect of ambiguous region length, with a higher percentage of ''yes'' responses in the long condition (47.4%) than in the

TABLE 2
Percentage Incorrect ''Yes'' Responses, Confidence Rating, and Question Response Time Data for Experiment 1a

	Garden path				Non-garden path	
	Plausible		Implausible			
Measure	Short	Long	Short	Long	Short	Long
Percentage ''yes'' (%)						
M	44.0	51.2	20.2	43.7	21.4	31.0
SD	0.30	0.33	0.25	0.31	0.22	0.25
Confidence rating (1–4)						
''No'' responses						
M	3.30	3.12	3.55	3.50	3.57	3.55
n	35	31	35	33	36	35
SD	0.56	0.82	0.48	0.48	0.49	0.48
''Yes'' responses						
M	3.23	3.25	3.29	3.17	2.81	3.08
n	31	30	21	31	25	29
SD	0.78	0.60	0.69	0.75	0.77	0.76
Question response time (sec)						
''No'' responses						
M	3.58	3.82	3.16	3.42	3.07	2.93
n	35	31	35	33	36	35
SD	1.54	2.40	1.22	1.63	1.66	1.23
''Yes'' responses						
M	3.84	3.17	3.23	3.36	4.05	3.45
n	31	30	21	31	25	29
SD	2.08	1.36	2.14	1.36	2.67	2.00

Note. There were a number of empty cells in the confidence and question response time data, both of which were conditionalized on either yes or no responses. Thus, we report the mean based on the available data in each condition and the number of participants contributing to that mean.

short condition (32.1%), $F1(1, 35) = 24.21$, $p < .001$; $F2(1, 41) = 36.65$, $p < .001$. The plausibility factor also produced a reliable effect, with a higher percentage of ''yes'' responses in the plausible condition (47.6%) compared to the implausible condition (32.0%), $F1(1, 35) = 21.84$, $p < .001$; $F2$ (1, 41) = 25.55, $p < .001$. Finally, there was a reliable interaction between these factors; the length effect for implausible sentences (23.5%) was larger than that for plausible sentences (7.2%), $F1(1, 35) = 10.46$, $p < .005$; $F2(1, 41) = 6.76$, $p < .05$.

We next compared each of the garden path plausibility conditions to the non-garden path control. For plausible garden path sentences compared to the control, there was a main effect of garden path, with a higher percentage of ''yes'' responses in the plausible garden path condition (47.6%) than in the control condition (26.2%), $F1(1, 35) = 26.38$, $p < .001$; $F2(1, 41) = 49.92$, $p < .001$. In addition, there was a main effect of ambiguous region length, with a higher percentage of ''yes'' responses in the long condition (41.1%) compared to the short condition (32.7%), $F1(1, 35) = 11.21$, $p < .005$; $F2(1, 41) = 9.36$, $p < .005$. These factors did not interact, Fs < 1.

For the implausible garden path sentences compared to the non-garden path control, the effect of garden path was not reliable by participants but approached reliability by items, with 26.2% ''yes'' responses in the control condition and 32.0% ''yes'' responses in the implausible garden path condition, $F1(1, 35) = 1.72$, $p > .20$; $F2(1, 41) = 3.90$, $p = .05$. In addition, there was main effect of ambiguous region length, with a higher percentage of ''yes'' response in the long condition (37.3%) than in the short condition (20.8%), $F1(1, 35) = 36.49$, $p < .001$; $F2(1, 41) = 28.63$, $p < .001$. These factors produced a reliable interaction; the length effect for implausible garden path sentences (23.5%) was larger than that for control sentences (9.6%), $F1(1, 35) = 6.44$, $p < .05$; $F2(1, 41) = 7.05$, $p < .05$.

Confidence ratings. Overall, participants were very confident in their responses, with a mean rating across all conditions and responses of 3.41 on a scale where 1 indicates *not at all confident* and 4 indicates *very confident*. We examined confidence for ''yes'' and ''no'' responses separately. These data are reported in Table 2. Participants tended to be more confident in ''no'' responses in those conditions with a higher proportion of ''no'' responses. Critically, in the garden path conditions for which there were a large proportion of ''yes'' responses, participants were quite confident in both ''no'' and ''yes'' responses, indicating that apparent misinterpretations in the garden path conditions were unlikely to have been the result of guessing.

Question response time. We examined question response time for ''yes'' and ''no'' responses separately. These data are presented in Table 2. Participants were typically faster to respond ''no'' in conditions in which there were a greater proportion of ''no'' responses.

Experiment 1b Results

Percentage ''yes'' responses. The percentage of incorrect ''yes'' responses in each condition is shown in Table 3. We first examined the garden path sentences. There was a main effect of ambiguous region length, with a higher percentage of ''yes'' responses in the long condition (37.5%) than in the short condition (19.9%), $F1(1, 35) = 26.66$, $p < .001$; $F2(1, 41) = 32.67$, $p < .001$. The plausibility factor also produced a reliable effect, with a higher percentage of ''yes'' responses in the plausible condition (36.1%) compared to the implausible condition (21.2%), $F1(1, 35) = 21.30$, $p < .001$; $F2\ (1, 41) = 22.97$, $p < .001$. These factors did not interact, $F1 < 1.6$; $F2 < 1$.

TABLE 3
Percentage Incorrect ''Yes'' Responses, Confidence Rating, Sentence Reading Time, and Question Response Time Data for Experiment 1b

	Garden path				Non-garden path	
	Plausible		Implausible			
Measure	Short	Long	Short	Long	Short	Long
Percentage ''yes'' (%)						
M	28.6	43.7	11.1	31.4	10.7	16.3
SD	0.24	0.34	0.18	0.24	0.14	0.17
Confidence rating (1–4)						
''No'' responses						
M	3.36	3.10	3.59	3.44	3.60	3.39
n	35	34	36	36	36	36
SD	0.64	0.84	0.63	0.66	0.62	0.69
''Yes'' responses						
M	3.21	3.25	2.85	2.99	2.61	3.20
n	27	29	16	28	16	23
SD	0.72	0.67	1.01	0.78	1.18	0.88
Question response time (sec)						
''No'' responses						
M	2.58	2.43	2.17	2.14	2.18	2.23
n	35	34	36	36	36	36
SD	1.09	0.93	0.74	0.88	0.68	0.72
''Yes'' responses						
M	3.10	2.36	2.69	2.31	2.48	2.51
n	27	29	16	28	16	23
SD	1.20	0.76	0.99	0.97	1.07	1.52
Sentence reading time (sec)						
M	3.50	5.21	3.80	5.46	4.01	5.38
SD	0.85	1.24	0.98	1.35	0.97	1.19

Note. There were a number of empty cells in the confidence and question response time data, both of which were conditionalized on either yes or no response. Thus, we report the mean based on the available data in each condition and the number of participants contributing to that mean.

We next compared each of the garden path plausibility conditions to the non-garden path control. For plausible garden path sentences compared to the control condition, there was a main effect of garden path, with a higher percentage of ''yes'' responses in the plausible garden path condition (36.1%) than in the control condition (13.5%), $F1(1, 35) = 36.63, p < .001$; $F2(1, 41) = 56.45, p < .001$. In addition, there was main effect of ambiguous region length, with a higher percentage of ''yes'' responses in the long condition (30.0%) compared to the short condition (19.7%), $F1(1, 35) = 15.75$, $p < .001$; $F2(1, 41) = 11.70, p < .005$. These factors produced an interaction that was reliable by items and marginally reliable by participants, $F1(1, 35) = 3.37, p = .07$; $F2(1,41) = 4.52, p < .05$. The length effect for plausible garden path sentences (15.1%) was larger than that for non-garden path sentences (5.6%).

For implausible garden path sentences compared to the non-garden path control, there was a main effect of garden path, with a higher percentage of ''yes'' responses in the implausible garden path condition (21.2%) than in the control condition (13.5%), $F1(1, 35) = 9.19$, $p < .005$; $F2(1, 41) = 7.61$, $p < .005$. In addition, there was a main effect of ambiguous region length, with a higher percentage of ''yes'' responses in the long condition (23.8%) than in the short condition (10.9%), $F1(1, 35) = 32.69$, $p < .001$; $F2(1, 41) = 26.69$, $p < .001$. These factors produced a reliable interaction; the length effect for implausible garden path sentences (20.3%) was larger than that for control sentences (5.6%), $F1(1, 35) = 10.65$, $p < .005$; $F2(1, 41) = 11.27$, $p < .005$.

Confidence ratings. As in Experiment 1a, participants were very confident in their responses, with a mean rating across all conditions and responses of 3.41. Confidence ratings were calculated for ''yes'' and ''no'' responses independently. These data are presented in Table 3. Confidence in ''no'' responses was generally higher in conditions with a greater proportion of ''no'' responses. We were most interested in confidence for correct and incorrect responses in the garden path conditions with a high proportion of incorrect ''yes'' responses (e.g., the plausible garden path condition). Participants were not only quite confident in their correct ''no'' responses but also in their incorrect ''yes'' responses.

Question response time. Mean question response times for correct ''no'' responses are presented in Table 3. Participants were typically faster to respond ''no'' in conditions in which there were a greater proportion of ''no'' responses.

Sentence reading time. We were also able to compute sentence reading time. This measure reflected the elapsed time from the onset of the sentence to the participant's button press to proceed to the question. These data are presented in Table 3. Hardly surprisingly, reading time was longer in conditions with a longer sentence. Because sentence length was not controlled across conditions, we did not conduct statistical analyses of these data.

Discussion

In Experiments 1a and 1b we investigated the interpretation of garden path sentences such as (2). For both RSVP and full sentence presentation, participants were quite likely to incorrectly answer ''Yes, the man hunted the deer'' following this sort of garden path sentence. Critically, this tendency to answer ''yes'' was greater in the garden path condition than it was in the non-garden path control condition, suggesting that the effect depends on an initial garden path. This tendency to answer ''yes'' to questions following garden path sentences was mediated both by the plausibility of the final interpretation of the sentence and by the length of the ambiguous region. When the interpretation of *the deer* NP as theme of the subordinate verb was implausible given the continuation provided by the matrix clause, participants were significantly less likely to answer ''yes'' incorrectly and in fact were not much more likely to answer ''yes'' than in the non-garden path control. In addition, reliably more ''yes'' responses were observed following sentences with a long ambiguous region compared to a short ambiguous region. Importantly, participants were nearly as confident in incorrect ''yes'' responses as they were in correct ''no'' responses. Given that participants often responded ''yes'' to the probe questions and were quite confident in these incorrect ''yes'' responses, the current data provide evidence that participants' interpretations often reflected the persistence of initial thematic role assignments in the absence of full syntactic reanalysis.

The striking aspect of the results from Experiments 1a and 1b is that subjects were quite poor at arriving at an interpretation licensed by the input string, yet surprisingly confident that they had correctly understood the sentences. What seems paramount is that the interpretation be plausible. Either way, it appears that quite often one's ultimate interpretation of a garden path sentence can result from an incomplete reanalysis. In particular, not all necessary revision took place. The longer the parser had been committed to the wrong syntactic analysis—that is, the earlier the head of the misanalyzed ambiguous phrase occurred—the more likely the comprehenders were to indicate that they believed the man was hunting the deer. Thus, it appears that the syntactic variable of head position and the semantic influence of ultimate pragmatic plausibility influenced the extent to which comprehenders were content to leave in place the initial interpretation built from the incorrect parse (see also Pickering & Traxler, 1998).

EXPERIMENT 2

We have so far presented the results of Experiments 1a and 1b as evidence that participants retain an interpretation based on the initial incorrect syntactic analysis. However, it could be argued that we merely have evidence that

the deer is being interpreted exclusively as the direct object and theme of the subordinate verb. As such, nothing at all, or at least nothing interpretable, serves as the subject and agent of the matrix verb (i.e., no reanalysis was performed whatsoever). The model proposed by Stevenson (1998; see also Lewis, 1998; Pritchett, 1992) predicts just this; her model chooses ''an empty (and unbound) subject for the matrix clause'' (p. 355) in garden path circumstances such as the ones we have focused on here. To discriminate between these two possibilities, in half of the Experiment 2 trials we asked comprehension questions that tapped into whether the main clause has an appropriate subject, e.g., *Did the deer run into the woods?* For the other half, we asked a question probing interpretation of the subordinate clause, e.g., *Did the man hunt the deer?,* as in Experiments 1a and 1b.

In addition, it might be possible to argue that the specific effect of ambiguous region length was due not to the length of time committed to an incorrect thematic role assignment, but rather to the fact that long ambiguous region sentences were simply longer than short ambiguous region sentences and thus more difficult to interpret. This alternate explanation finds some initial support in the fact that there was an effect of ambiguous region length not only for the garden path conditions but also for the non-garden path condition (see also Ferreira & Henderson, 1991, 1998). However, comparison of both the plausible garden path and implausible garden path conditions to the non-garden path control revealed that the ambiguous region length effect was larger for the garden path conditions than for the control condition. To investigate this issue further, in Experiment 2 we manipulated the position of the head of the ambiguous NP as a converging method of varying the length of time committed to the wrong analysis. In a series of experiments, Ferreira and Henderson (1991, 1998) demonstrated that if the head of a phrase occurs early within it, reanalysis is much harder than if the head occurs at the end of the phrase. Consider (3)–(6), where (3) and (4) are equivalent in terms of the ease with which they can be reanalyzed (as measured by grammaticality judgments in Ferreira & Henderson), and both are easier than (4) and (6), which are equivalent to one another in their relative difficulty of reanalysis:

(3) While the man hunted the deer ran into the woods.
(4) While the man hunted the brown and furry deer ran into the woods.
(5) While the man hunted the deer with large antlers ran into the woods.
(6) While the man hunted the deer that was brown and furry ran into the woods.

Thus, the sheer number of words intervening between the thematic assigner (verb) and the thematic assignee (noun) does not appear to be critical, as evidenced by the lack of contrast between (3) and (4); nor is the syntactic complexity of the ambiguous region crucial, as seen in the lack of contrast between (5) and (6), where the ambiguous region of the former contains only phrasal nodes, whereas that of the latter contains both phrasal and clausal

nodes. Rather, the crucial difference between (3)/(4) and (5)/(6) is the position of the head of the misanalyzed phrase. Ferreira and Henderson proposed that thematic roles are assigned at heads, and so if the head is located earlier in the misanalyzed phrase, the incorrect thematic role will have been attached to that phrase for a longer time once the disambiguating error signal is encountered. It is head position, then, that accounts for the disparity between (3) and (6), with (3)/(4) being relatively easier to reanalyze because in each the thematic role is only assigned to *the deer* for a shorter time before disambiguating input occurs. Based on Ferreira and Henderson's (1991, 1998) results, we expected reanalysis to be more difficult when the head occurred early rather than late, and so we predicted that accuracy at answering the question about the subordinate clause would be compromised as well.

As a final manipulation, we created sentences that reversed the order of the subordinate and main clause, as shown in (7):

(7) The deer (that was brown and graceful) ran into the woods while the man hunted.

The purpose of this manipulation was to assess further the extent to which the comprehenders' tendency to say that the man was hunting the deer was due to the syntactic misanalysis in addition to pragmatic plausibility. One might expect the pragmatic inference to be stronger for sentences such as (7) (especially the long version), since the relative order of *the deer* and *hunted* in (7), combined with the addition of detail in the relative clause in some stimuli sentences, can only serve to enhance the conversational implicature that *the deer* is what is being hunted. In Experiment 2, we addressed this line of reasoning by comparing sentences such as (7) with garden path sentences such as (3). Sentences with subordinate-matrix clause order, such as those in Experiments 1a and 1b, create a garden path, whereas sentences with matrix-subordinate order do not [e.g., (7) above]. Thus, the matrix-subordinate sentences serve as a control in that they carry the same informational load as the garden path sentences and should therefore elicit the same inference (i.e., that it is *the deer* that *the man* was hunting), yet they do not create a garden path.

For this experiment, then, we made three changes to the design of Experiments 1a and 1b. First, a condition was added in which the question probed interpretation of the matrix clause of the experimental sentence rather than interpretation of the subordinate clause. Second, we replaced the ambiguous region length manipulation with a manipulation of head position in the ambiguous NP, as illustrated in (4) and (6) above. Third, we added a control condition in which the clause order of the original garden path sentences was reversed.

Method

Participants. Twenty-four Michigan State University undergraduate students participated for course credit. All participants were native speakers of English and were naïve with respect to the hypotheses under investigation. None had participated in previous experiments.

TABLE 4
Sample Item in Experiment 2

Sentence
Subordinate-matrix, head late
As Harry chewed the brown and juicy steak fell to the floor.
Subordinate-matrix, head early
As Harry chewed the steak that was brown and juicy fell to the floor.
Matrix-subordinate, head late
The brown and juicy steak fell to the floor as Harry chewed.
Matrix-subordinate, head early
The steak that was brown and juicy fell to the floor as Harry chewed.
Question:
About subordinate clause
Did Harry chew the steak?
About matrix clause
Did the steak fall to the floor?

Materials. Each sentence item appeared in one of eight conditions. These conditions are illustrated in Table 4. The first change to the materials in Experiments 1a and 1b was the addition of a condition in which the question probed interpretation of the matrix clause (*Did the steak fall to the floor?* in the example in Table 4). In addition, clause order was manipulated so that the subordinate clause came either before the matrix clause (as in Experiments 1a and 1b) or after the matrix clause. Finally, the head of the ambiguous NP could either appear early in that phrase (steak that was brown and juicy) or late in that phrase (brown and juicy steak).

A total of 40 different sentence items was used, drawn from the original 42 in Experiments 1a and 1b. These are listed in Appendix 1. Each participant saw only one version of each sentence item but saw an equivalent number of items in each condition. Across participants, each sentence item appeared in each condition an equal number of times. The experimental items were presented along with the same 92 filler sentences used in Experiments 1a and 1b.

Apparatus and procedure. The apparatus and procedure were the same as those in Experiment 1b.

Results

Percentage errors. The percentages of incorrect responses in each condition are shown in Table 5. For questions about the subordinate clause, the correct response was ''no.'' For questions about the matrix clause, the correct response was ''yes.'' The data were entered into a $2 \times 2 \times 2$ (question type $\times$ clause order $\times$ head position) ANOVA. First, there was a main effect of question type, with more incorrect responses when the question probed interpretation of the subordinate clause (55.6%) compared to the matrix clause (9.4%), $F1(1, 23) = 70.08$, $p < .001$; $F2(1, 39) = 165.73$, $p < .001$. In addition, there was a main effect of clause order, with more incorrect responses in the subordinate-matrix condition (36.9%) than in the matrix-subordinate condition (28.1%), $F1(1, 23) = 13.58$, $p < .005$; $F2(1, 39) = 14.60$, $p < .001$. There was also a main effect of head position, with more incorrect responses in the head early condition (36.7%) than in the head late

TABLE 5
Percentage Errors, Confidence Rating, Question Response Time and Sentence Reading Time Data for Experiment 2

	Subordinate clause question				Matrix clause question			
	Sub.-matrix head		Matrix-sub. head		Sub.-matrix head		Matrix-sub. head	
Measure	Late	Early	Late	Early	Late	Early	Late	Early
Percentage errors (%)								
M	50.8	73.3	47.5	50.8	8.3	15.0	6.7	7.5
SD	0.33	0.23	0.28	0.29	0.14	0.18	0.14	0.12
Confidence rating (1–4)								
''No'' responses								
M	2.87	2.96	2.97	2.89	2.86	2.57	2.60	3.06
n	21	17	22	23	7	12	5	8
SD	0.77	0.63	0.76	0.66	0.90	0.74	0.96	0.94
''Yes'' responses								
M	2.95	3.41	2.96	3.01	3.62	3.39	3.67	3.64
n	22	24	22	21	24	24	24	24
SD	0.90	0.50	0.83	0.73	0.32	0.71	0.37	0.34
Question response time (sec)								
''No'' responses								
M	2.94	2.68	3.16	3.09	3.19	2.96	2.83	2.93
n	21	17	22	23	7	12	5	8
SD	0.76	0.72	1.15	1.04	0.44	0.63	1.25	1.08
''Yes'' responses								
M	2.91	2.15	3.08	2.88	2.17	2.23	2.05	2.05
n	22	24	22	21	24	24	24	24
SD	1.11	0.69	1.22	0.83	0.60	1.05	0.54	0.53
Sentence reading time (sec)								
M	4.33	4.48	3.88	4.32	4.22	4.55	3.90	4.22
SD	0.87	0.70	0.74	0.72	0.69	0.97	0.78	0.78

Note. The correct response for questions about the subordinate clause was ''no,'' and the correct response for questions about the matrix clause was ''yes.'' There were a number of empty cells in the confidence and question response time data, both of which were conditionalized on either yes or no responses. Thus, we report the mean based on the available data in each condition and the number of participants contributing to that mean.

condition (28.3%), $F1(1, 23) = 24.21, p < .001$; $F2(1, 39) = 10.39, p < .005$.

In addition to these main effects, there was an interaction between question type and clause order that was reliable by participants and marginally reliable by items, $F1(1, 23) = 4.29, p < .05$; $F2\ (1, 39) = 3.62, p = .06$. The clause order effect was larger for questions about the subordinate clause (12.9%) compared to questions about the matrix clause (4.6%). There was also an interaction between question type and head position that was marginally reliable both by participants and items, $F1(1, 23) = 3.18, p = .08$; $F2\ (1, 39) =$

3.33, $p = .07$. The head position effect was larger for questions about the subordinate clause (12.9%) compared to questions about the matrix clause (3.8%). Finally, there was a reliable interaction between clause order and head position, with a larger head position effect in the subordinate-matrix condition (14.6%) compared to that in the matrix-subordinate condition (2.1%), $F1(1, 23) = 6.71$, $p < .05$; $F2$ $(1, 39) = 6.68$, $p < .05$.

In addition to the global analysis, we conducted specific analyses for each question type condition. For questions about the matrix clause, there was an effect of clause order that was marginally reliable by participants and items, $F1(1, 23) = 3.87$, $p = .06$; $F2(1, 39) = 2.81$, $p = .10$. There was a higher percentage of incorrect ''no'' responses in the subordinate-matrix condition (11.7%) compared to that in the matrix-subordinate condition (7.1%). No other effects were reliable. For questions about the subordinate clause, there was a main effect of clause order, with more incorrect ''yes'' responses in the subordinate-matrix condition (62.1%) compared to the matrix-subordinate condition (49.2%), $F1(1, 23) = 11.97$, $p < .005$; $F2(1, 39) = 13.22$, $p < .005$. In addition, there was a main effect of head position, with a higher percentage of ''yes'' responses in the head early condition (62.1%) than in the head late condition (49.2%), $F1(1, 23) = 14.18$, $p < .005$; $F2(1, 39) = 8.44$, $p < .01$. Finally, these factors produced a reliable interaction, $F1(1, 23) = 5.57$, $p < .05$; $F2(1, 39) = 7.40$, $p < .01$. The head position effect was larger for subordinate-matrix sentences (22.5%) than for matrix-subordinate sentences (3.3%).

Confidence ratings. As in previous experiments, participants were very confident in their responses, with a mean rating across all conditions and responses of 3.28. Confidence ratings were calculated for ''yes'' and ''no'' responses independently. These data are presented in Table 5. Confidence in correct responses tended to be higher in conditions with a greater proportion of correct responses. Importantly, confidence in incorrect ''yes'' responses when asked about the verb of the subordinate clause in the garden path sentences was no lower than that for correct ''no'' responses in those conditions. Thus, misinterpretations appeared to be confidently held.

Question response time. Question response time data are presented in Table 5. We could only examine question response within each question type condition since question length was not controlled across the two. The analysis of the question response time for correct ''yes'' responses to questions about the matrix clause did not reveal any reliable effects. Mean response time was 2.18 s. The analysis of the question response time for correct ''no'' responses to questions about the subordinate clause did not produce any reliable effects. Mean response time was 2.86 s.

Sentence reading time. Sentence reading time data are presented in Table 5. The only factor of interest was clause order. Question type obviously should not influence sentence reading times (and it did not), and the head position manipulation could not be analyzed due to the fact that head early

sentences had two more words than head late sentences. The clause order contrast, however, produced a reliable effect, $F1(1, 23) = 9.17$, $p < .01$; $F2(1, 39) = 15.18$, $p < .001$. Participants were slower to read sentences in the subordinate-matrix condition (4.40 s) compared to the matrix-subordinate condition (4.08 s). This difference was consistent with our assumption that participants would be garden pathed in the former condition but not the latter.

Discussion

The first issue at stake in Experiment 2 was whether people are able to reassign the object NP of the subordinate clause to subject position (and agent thematic role) of the matrix clause. A number of parsing models attribute the difficulty of this sort of garden path sentence to the fact that the parser has trouble incorporating the subject/agent into the syntactic representation of the matrix clause. It is not, in these accounts, difficult to detach the initial object/theme or to revise the thematic grid of the verb in the subordinate clause. The data from Experiment 2, however, suggest that people incompletely reanalyze the NP in question, raising it to subject position in the matrix clause with little or no difficulty, but not immediately erasing it from object position of the subordinate clause. When asked comprehension questions about the matrix clause, subjects answered correctly (i.e., they had arrived at the syntactically licensed interpretation) approximately 90% of the time. Recall that this finding is consistent with the account proposed by Fodor and Inoue (1998) discussed in the Introduction. ''Stealing'' the NP *the deer* away from the subordinate clause is automatic, since the matrix clause requires a subject. The process of ''Adjust,'' whereby the aftermath of the stealing is cleaned up, however, must continue long enough to complete a full reanalysis. If it does not, Fodor and Inoue predict that ''a stable state is not always reached'' (1998, p. 106) which, our data show, apparently refers to persistent misinterpretation.

The second issue in Experiment 2 was the effect of head position. The percentage of ''yes'' responses was higher for garden path sentences when the head appeared early in the ambiguous region compared to when it appeared later in that region. These results replicate the grammaticality judgment results of Ferreira and Henderson (1991). Moreover, the fact that the head position effect was reliably larger in the subordinate-matrix clause order than in the matrix-subordinate clause order suggests that head position specifically influences reanalysis (as opposed to, say, initial parse of an embedded clause vs a prepositional phrase).

The final issue at stake in Experiment 2 was whether general reasoning based on purely pragmatic principles could account for subjects consistently and confidently interpreting the ambiguous NP as the object and theme of the subordinate verb. If full reanalyses were not being carried out simply because the resultant interpretations were based on the Gricean maxim of relation (relevance) (Grice, 1975), or even some sort of ''general reasoning,''

then this preference for pragmatics should also be apparent in interpretation of the same sentences but with reversed clause order. If, on the other hand, the incorrect interpretations stem from the syntactic parse of the garden path sentences, we would expect a significant difference between the rates of ''yes'' and ''no'' answers to the question, *Did the man hunt the deer?* in the two clause-order conditions. The results show that the tendency to believe the man is hunting the deer is due to a combination of the syntactic misanalysis and the pragmatic plausibility of the inference. Although the pattern of results for questions about the subordinate clause in matrix-subordinate sentences followed those in subordinate-matrix sentences, subjects were significantly less likely to answer ''yes'' incorrectly in the former. In addition, we obtained an interaction between clause order and the purely syntactic factor of head position: Misinterpretations occurred more often when the head of the misanalyzed phrase occurred early, indicating that comprehenders were more likely to cling to the interpretation the longer they had been committed to it.

EXPERIMENTS 3a AND 3b

In these final experiments, we investigated the phenomenon of incomplete reanalysis using a unique class of verbs such as *bathe* (in addition to the more typical, optionally transitive verbs used in Experiments 1 and 2). These verbs are traditionally referred to as semireflexive verbs (Quirk, Greenbaum, Leech, & Svartvik, 1985) or Reflexive Absolute Transitive (RAT) verbs (Trask, 1993). Verbs in this class generally denote actions dealing with personal hygiene, e.g., *wash, bathe, shave, scratch,* and *groom* and a few that do not, e.g., *hide*. RAT verbs contrast syntactically with optionally transitive verbs such as *hunt* or *eat* in a number of ways. First, in the absence of a direct object, only RAT verbs are obligatorily understood as reflexive (i.e., can take a reflexive pronoun as direct object with no associated change in meaning), as illustrated in (8) and (9):

(8) *Bill bathed all day = Bill bathed himself all day.*
(9) *Bill hunted all day. ≠ Bill hunted himself all day.*

Second, in sentences such as (10) and (11), the possible coreferential relations are the same whether there occurs an explicit anaphor (reflexive pronoun) as theme or not. Higginbotham (1997) proposed that in the latter case, coreference holds between syntactic elements (*Jack* and *Bill*), an empty category (*PRO*) (cf. Chomsky, 1986), and the implicit theme. (* marks an ungrammatical interpretation, and ∅ signifies an open position in the verb's thematic grid.)[1]:

[1] Alternatively, Wilkins (1988) argues that such verbs actually assign, via a referential mechanism, two distinct thematic roles to the NP in subject position. Even if this analysis is correct,

(10) *Jack*$_j$ *persuaded Bill*$_i$ PRO$_{*j/i}$ *to bathe himself*$_{*j/i}$/ $\varnothing_{*j/i}$
(11) *Jack*$_j$ *promised Bill*$_i$ PRO$_{j/*i}$ *to bathe himself*$_{j/*i}$/$\varnothing_{j/*i}$

Thus, the linguistic analysis of these verbs makes clear that even without an overt object as theme (i.e., the intransitive structure), the verb contains an understood object that must be interpreted as reflexive. The relevance of this observation for our experiment is that garden path sentences containing such verbs in the subordinate clause do not provide the lexical opportunity to interpret the verb as having an unspecified, general object.

RAT verbs, then, do not allow the same inference that can be drawn with optionally transitive verbs—the inference that because *the man* was hunting in general, it is likely that *the deer* was the quarry of his hunt, even though it is not the overt object of the verb *hunt*. But if the RAT verb *dressed* in *While Anna dressed the baby that was small and cute spit up on the bed* is fully reanalyzed so as to include the obligatory reflexive object (covert in this case), it is impossible to reason that Anna is dressing the baby. This becomes strikingly clear if one reverses the clause order. *The baby that was small and cute spit up on the bed while Anna dressed* does not appear to allow the interpretation that Anna dressed the baby. In addition, RAT verbs are immune from contextual bias that might lead to an inferentially determined interpretation:

(12) *The refrigerator was filled with beer, so Jack drank all day*
(Inference: Jack drank beer all day)
(13) *The dog was covered with fleas, so Jack scratched all day*
(Inference CANNOT be: Jack scratched the dog all day)[2]

In (13) the only inference that can be made is that Jack was given fleas by the dog and therefore scratched himself all day. This rather complex chain of inference appears to be taxing as well, since at first blush (13) seems semantically anomalous compared to (12).

Thus, if we were still to find a large proportion of ''yes'' responses in the garden path sentences containing RAT verbs, this would be very strong evidence for a syntactic locus of the persistent misinterpretations and against an explanation based on general reasoning. An exhaustive reanalysis process would yield a syntactic representation immune from pragmatically based inferences. Only an incomplete reanalysis would result in incorrect ''yes'' responses.

In Experiment 3a we compared the garden path sentences to the same

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the situation that is crucial remains: RAT verbs have only one argument structure, be it a transitive one or an intransitive one. Multiple thematic role assignment to a single NP is also suggested in Broadwell's (1988) analysis of Choctaw. However, in Choctaw, it is the case that one verb assigns two thematic roles to one NP, not, as in the experimental sentences in Experiments 1–2, two distinct thematic roles from two different verbs.

[2] Fodor and Inoue (1998) use the verb *scratch* as an example of an optionally transitive verb, but it is in fact a RAT verb such as *bathe*.

TABLE 6
Sample Items in Experiments 3a and 3b

RAT	
Garden path (subordinate-matrix)	*While Anna dressed the baby that was small and cute spit up on the bed.*
Experiment 3a control (matrix-subordinate)	*The baby that was small and cute spit up on the bed while Anna dressed.*
Experiment 3b control (subordinate-matrix with disambiguating comma)	*While Anna dressed, the baby that was small and cute spit up on the bed.*
Question	Did Anna dress the baby?
Optionally transitive	
Garden path (subordinate-matrix)	*While Susan wrote the letter that was long and eloquent fell off the table.*
Experiment 3a control (matrix-subordinate)	*The letter that was long and eloquent fell off the table while Susan wrote.*
Experiment 3b control (subordinate-matrix with disambiguating comma)	*While Susan wrote, the letter that was long and eloquent fell off the table.*
Question	Did Susan write the letter?

sentences but with the reverse clause order, as in Experiment 2. The Experiment 3a conditions are listed in Table 6. The reasoning behind this manipulation was to determine the absolute strength of pragmatic information in arriving at an interpretation of non-garden path sentences. Recall that although there were significantly fewer incorrect responses in Experiment 2 in the matrix-subordinate clause order condition, the pattern of the data mirrored that of the subordinate-matrix clause order condition. Again, in the case of RAT verbs, the syntactic properties of the verb prohibit any sort of interpretation other than the reflexive one, despite pragmatic relevance issues.

In Experiment 3b we compared the garden path sentences to the same sentences but with a disambiguating comma after the verb of the subordinate clause, illustrated in Table 6. As with the clause order manipulation, the comma control condition prevents an initial garden path misanalysis and thus provides a measure of the absolute influence of the pragmatic information on sentence interpretation. The comma manipulation has an advantage over the clause order manipulation in that it is a relatively minor modification of the sentence, preserving word order. The clause order manipulation could conceivably influence such factors as focus or the length of time information must be maintained in memory prior to the probe question. The comma manipulation is not vulnerable to such confounds.

For both Experiments 3a and 3b, if the large number of apparent misinterpretations in the preceding experiments is due to incomplete reanalysis of initial thematic role assignments (rather than being due to inferences based on general reasoning or pragmatics), then we should find two effects. First,

there should be a significant number of ''yes'' responses for both optionally transitive and RAT verbs. Second, we should find a greater percentage of ''yes'' responses for garden path sentences compared to non-garden-pathing control sentences that do not induce an initial misassignment of thematic roles.

Method

Participants. Sixteen Michigan State University undergraduate students participated in Experiment 3a, and 16 different students participated in Experiment 3b, all for course credit. Participants were native speakers of English and were naïve with respect to the hypotheses under investigation. None had participated in the previous experiments.

Materials. Two types of sentence items were employed: the critical verb was either an optionally transitive verb or an RAT verb. All sentences had a long ambiguous region in which the head of the ambiguous NP appeared early in the phrase. A total of 24 different sentence items was created, 12 with an optionally transitive verb and 12 with an RAT verb. The sentences with an optionally transitive initial verb were drawn from the original 42 used in Experiments 1a and 1b. These materials are listed in Appendix 1.

For Experiment 3a, each sentence item appeared in two clause order conditions: subordinate-matrix (garden path) and matrix-subordinate (non-garden path). For Experiment 3b, only the subordinate-matrix clause order was employed. The non-garden path control condition was created by adding a disambiguating comma after the verb of the subordinate clause.

Each participant saw only one version of each sentence item but saw an equivalent number of items in each condition. Across participants, each sentence item appeared in each condition an equal number of times. The experimental items were presented along with the same 92 filler sentences as used in Experiments 1–2. For Experiment 3b, a comma was added after the verb of the subordinate clause for half of the filler sentences with the subordinate-matrix clause order.

Apparatus and procedure. The apparatus and procedure were the same as in Experiment 1b.

Experiment 3a Results

Percentage ''yes'' responses. The percentage of incorrect ''yes'' responses in each condition is shown in Table 7. First there was a main effect of verb type, with a higher percentage of ''yes'' responses for optionally transitive verbs (62.0%) than for RAT verbs (39.1%), $F1(1, 15) = 35.61$, $p < .001$; $F2(1, 22) = 19.47$, $p < .001$. In addition, there was a main effect of clause order, with a higher percentage of ''yes'' responses in the subordinate-matrix condition (70.3%) than in the matrix-subordinate condition (30.7%), $F1(1, 15) = 40.11$, $p < .001$; $F2(1, 22) = 55.64$, $p < .001$. These factors produced a reliable interaction, $F1(1, 15) = 13.87$, $p < .001$; $F2(1, 22) = 6.51$, $p < .05$. To investigate this interaction more closely, we examined each of the four contrasts possible under this design. First, the effect of clause order was reliable both for RAT verbs (53.1%), $F1(1, 15) = 41.74$, $p < .001$; $F2(1, 11) = 51.55$, $p < .001$, and for optionally transitive verbs (26.0%), $F1(1, 15) = 18.35$, $p < .001$; $F2(1, 11) = 11.71$, $p < .01$. Second the effect of verb type was reliable in the matrix-subordinate condition (36.5%), $F1(1, 15) = 37.72$, $p < .001$; $F2(1, 23) = 18.43$, $p < .001$. In the

TABLE 7
Percentage Incorrect ''Yes'' Responses, Confidence Rating, Question Response Time, and Sentence Reading Time Data for Experiment 3a

Measure	RAT verb		Optionally transitive verb	
	Sub.-matrix	Matrix-sub.	Sub.-matrix	Matrix-sub.
Percentage ''yes'' (%)				
M	65.6	12.5	75.0	49.0
SD	0.31	0.20	0.27	0.20
Confidence rating (1–4)				
''No'' responses				
M	3.30	3.10	2.94	2.59
n	11	16	9	16
SD	0.55	0.63	0.69	0.60
''Yes'' responses				
M	3.38	2.86	3.24	2.98
n	16	6	16	16
SD	0.75	1.02	0.73	0.83
Question response time (sec)				
''No'' responses				
M	2.41	2.63	2.38	3.14
n	11	16	9	16
SD	0.75	1.02	0.73	0.83
''Yes'' responses				
M	1.85	2.71	1.92	2.59
n	16	6	16	16
SD	0.43	1.13	0.52	0.65
Sentence reading time (sec)				
M	4.60	4.24	4.68	4.34
SD	0.81	0.83	0.99	0.74

Note. There were a number of empty cells in the confidence and question response time data, both of which were conditionalized on either yes or no responses. Thus, we report the mean based on the available data in each condition and the number of participants contributing to that mean.

subordinate-matrix condition, the verb type effect (9.4%) was marginally reliable by participants but was not reliable by items, $F1(1, 15) = 4.25, p = .054$; $F2(1, 23) = 2.30, p = .14$.

Confidence ratings. As in previous experiments, participants were quite confident in their responses, with a mean rating of 3.15 across all conditions and responses. Confidence ratings were calculated for ''yes'' and ''no'' responses independently. These data are presented in Table 7. Incorrect ''yes'' responses in the garden path conditions were no less confidently held than correct ''no'' responses.

Question response time. Question response time data are presented in Table 7. These data should be treated with some caution because question length was not controlled across RAT and optionally transitive conditions.

Sentence reading time. Sentence reading time data are presented in Table 7. The verb type manipulation could not be analyzed because RAT and optionally transitive sentences were not precisely controlled for length. However, there was a main effect of clause order, $F1(1, 15) = 4.50$, $p < .05$; $F2(1, 22) = 12.27$, $p < .005$. Participants were slower to read sentences in the subordinate-matrix condition (4.64 s) compared to the matrix-subordinate condition (4.29 s), consistent with our assumption that they would be garden-pathed in the former but not in the latter.

Experiment 3b Results

Percentage ''yes'' responses. The percentage of incorrect ''yes'' responses in each condition is shown in Table 8. First there was a main effect of verb type, with a higher percentage of ''yes'' responses for optionally transitive verbs (56.8%) than for RAT verbs (34.4%), $F1(1, 15) = 48.95$, $p < .001$; $F2(1, 22) = 11.94$, $p < .005$. In addition, there was a main effect of comma presence, with a higher percentage of ''yes'' responses in the comma absent condition (64.6%) than in the comma present condition (26.6%), $F1(1, 15) = 28.73$, $p < .001$; $F2(1, 22) = 154.67$, $p < .001$. These factors produced a reliable interaction, $F1(1, 15) = 4.69$, $p < .05$; $F2(1, 22) = 6.53$, $p < .05$. To investigate this interaction more closely, we examined each of the four possible contrasts. First, the effect of comma presence was reliable both for RAT verbs, $F1(1, 15) = 30.77$, $p < .001$; $F2(1, 11) = 106.48$, $p < .001$, and for optionally transitive verbs, $F1(1, 15) = 15.64$, $p < .005$; $F2(1, 11) = 51.68$, $p < .01$. Second, the effect of verb type was reliable both in the comma present condition, $F1(1, 15) = 42.79$, $p < .001$; $F2(1, 23) = 16.91$, $p < .001$, and in the comma absent condition, $F1(1, 15) = 8.45$, $p < .05$; $F2(1, 23) = 4.36$, $p < .05$.

Confidence ratings. As in previous experiments, participants were quite confident in their responses, with a mean rating of 3.38 across all conditions and responses. Confidence ratings were calculated for ''yes'' and ''no'' responses independently. These data are presented in Table 8. Critically, incorrect ''yes'' responses in the garden path conditions were no less confidently held than correct ''no'' responses.

Question response time. Question response time data are presented in Table 8. As in Experiment 3a, these data should be treated with caution because question length was not controlled across RAT and optionally transitive conditions.

Sentence reading time. Sentence reading time data are presented in Table 8. The verb type manipulation could not be analyzed because RAT and optionally transitive sentences were not precisely controlled for length. However, there was a main effect of comma presence, $F1(1, 15) = 12.89$, $p < .005$; $F2(1, 22) = 23.67$, $p < .001$. Participants were slower to read sentences in the comma absent condition (6.30 s) compared to the comma present con-

TABLE 8
Percentage Incorrect ''Yes'' Responses, Confidence Rating, Question Response Time, and Sentence Reading Time Data for Experiment 3b

	RAT verb		Optionally transitive verb	
Measure	Comma absent	Comma present	Comma absent	Comma present
Percentage ''yes'' (%)				
M	57.3	11.5	71.9	41.7
SD	0.36	0.22	0.32	0.28
Confidence rating (1–4)				
''No'' responses				
M	3.12	3.55	3.11	3.04
n	13	16	9	15
SD	0.70	0.65	0.69	0.72
''Yes'' responses				
M	3.14	3.28	3.38	3.33
n	13	6	16	14
SD	0.94	0.87	0.76	0.72
Question response time (sec)				
''No'' responses				
M	1.06	1.87	3.10	3.05
n	13	16	9	15
SD	1.31	1.36	2.10	2.21
''Yes'' responses				
M	2.40	3.06	2.70	3.73
n	13	6	16	14
SD	0.73	2.22	0.99	1.49
Sentence reading time (sec)				
M	6.28	5.37	6.32	5.36
SD	1.34	0.82	0.79	0.88

Note. There were a number of empty cells in the confidence and question response time data, both of which were conditionalized on either yes or no responses. Thus, we report the mean based on the available data in each condition and the number of participants contributing to that mean.

dition (5.37 s), consistent with our assumption that they would be garden-pathed in the former but not in the latter.

Discussion

RAT verbs provide a powerful test of the possibility that unlicensed interpretations of garden path sentences result from ''general reasoning'' rather than incomplete syntactic reanalysis. If full syntactic reanalysis were carried out, incorrect interpretations based on inference would be completely ruled out by the syntactic and thematic role assignment properties of the RAT verbs. Specifically, RAT verbs, unlike optionally transitive verbs, retain tran-

sitive argument structures even when no overt object occurs in the input stream and, in such cases, assign the thematic role to the open position in their theta grids.

The results of Experiments 3a and 3b provide unequivocal evidence that the syntactic relations that are first established in the initial parse and then not fully revised upon reanalysis lead to misinterpretation. Subjects incorrectly responded ''yes'' approximately 60% of the time in the RAT verb garden path sentences despite the fact that the general reasoning hypothesis cannot apply to such constructions. In addition, there was a remarkably large effect of clause order and comma presence for RAT verb sentences, suggesting that initial misanalysis is a function of the syntax of garden path constructions and that without a full reanalysis of the syntactic representation, the resultant misinterpretation will persist. In general, the RAT verbs behaved very similarly to the optionally transitive verbs, again despite the fact that the inference possible in the latter was blocked in the former. There was some limited evidence that garden path sentences with RAT verbs may be slightly less susceptible to misinterpretation than those with optionally transitive verbs, but the difference was very small compared to the overall size of the misinterpretation effect. In addition, these results underline the fact that subjects find initial misanalyses of such sentences extremely hard to recover from, even though detaching the initial NP attachment from the subordinate clause does not necessitate a revision of the RAT verb's argument structure. All that is required here is that the initial thematic role assignment be fully erased.

GENERAL DISCUSSION

The experiments we have described are among the first to have been conducted for the main purpose of exploring the *interpretation* of garden path sentences. A great deal of research has investigated how the individual words of sentences are processed as they are encountered (e.g., through the use of online measures of processing such as reading times), but measures of comprehension are usually treated as secondary. Indeed, in many reports, examples of the comprehension items are not provided and precise measures of accuracy are not given. The results of our experiments suggest that much can be learned about the architecture of the language processing system from comprehension measures.

The insights that emerge from our experiments include the following. First, we found that participants were accurate at answering questions about the subject and action of the main clause of a garden path sentence such as *While Anna dressed the baby spit up on the bed*. This finding is important because it reveals that the parser and comprehension system engaged in successful reanalysis to some extent: The question could not have been answered accurately unless the language system recognized the problem with the initial analysis and located an NP for the second clause (viz. by ''stealing'' it from

the preceding, subordinate clause à la Fodor & Inoue, 1998). Second, however, we also found that the comprehension system has some tendency to allow the interpretation based on the initial syntactic analysis of the subordinate clause to linger (e.g., the interpretation that Anna dressed the baby). Thus, it appears that the parser appropriately recruits the ambiguous NP for the matrix clause, but it does not consistently follow-up on its actions (via ''Adjust'') by giving up on the parse of the sentence according to which that same NP is object of the subordinate clause. Moreover, if that incorrect interpretation is pragmatically plausible, comprehenders are even less likely to give it up. In addition, the experiments determined that participants were more likely to accept the incorrect interpretation the longer they entertained the corresponding syntactic misanalysis. We have shown, then, that reanalysis is not an all-or-none proposition.

These findings suggest that confident, sentence-level comprehension can be obtained without full, consistent reanalysis on some level. Our data also clearly show that misinterpretation of these garden path sentences stems from initial incorrect syntactic analysis (rather than from general reasoning) and that the initial interpretation is often not abandoned in favor of the correct interpretation. Aside from the general reasoning story, however, several alternative accounts of the data presented here might be entertained. We take a moment here to discuss these alternatives and, ultimately, to abandon them in favor of an account that attributes the misinterpretation effect to problems at the syntactic level of representation.

One potential explanation for the large number of incorrect responses to the comprehension questions is that no reanalysis takes place at all: the vast majority of participants were wrong from start to finish and never attempted reanalysis, while the much smaller number who did answer correctly were the ones who both initiated and completed reanalysis. In other words, reanalysis is an all-or-nothing enterprise after all. The clearest piece of evidence against this stance is found in the results of Experiments 2, where participants were nearly perfect at identifying the subjects of the matrix clauses. Some degree of reanalysis must take place for the NP initially parsed as the object of the subordinate clause to be recruited as the subject of the matrix clause.

At the other extreme, suppose that full reanalysis *does* take place for the large majority of sentences. In this situation, the locus of the misinterpretation could be either syntactic or nonsyntactic. Taking the latter first, consider a state of affairs in which the fully reanalyzed structure and resultant correct interpretation is attained but competes with the initial incorrect structure and its resultant interpretation. The competition must then be settled according to nonsyntactic constraints, such as frequency and pragmatic appropriateness. A major question that would need to be answered under such an account is why recency does not affect the outcome of the competition. One would think that the most recent reanalysis of the ambiguous NP as subject of the matrix clause and not as object of the subordinate clause would fair better

in this competition, especially since that reanalysis indicates that the initial interpretation is likely to be incorrect. Additionally, if competing structures do exist, both of which map onto competing interpretations, we might expect confidence ratings to be lower—for both correct and incorrect responses—than they were in any of the experiments.

A second possibility is that although full reanalysis does take place, the resultant syntactic structure (specifically that of the subordinate clause) does not get mapped onto an appropriate, corresponding semantic representation. Such an explanation begs the question of why it would not, especially since part of the syntactic structure (the matrix clause) does proceed on to the semantics, as shown by the results of Experiment 2. A similar yet less extreme version of this story is that the single, correct reanalyzed syntactic structure does get mapped onto the semantics. However, when it comes time to evaluate the new and the old interpretations of the critical subordinate clause (the old one having not yet faded from short-term memory), the propositions get integrated because they are compatible. More precisely, because ''hunting the deer'' entails ''hunting something (some unspecified quarry),'' the two interpretations are merged. Although this would explain the optionally transitive verbs, and perhaps the plausibility effects from Experiment 1, it does not account for the data from the RAT verbs. Significantly, ''bathing the baby'' does *not* entail ''bathing oneself,'' even in cases where the actors are mother and child.

Returning, then, to the explanation discussed previously, we locate the problem at the syntactic level. Two options exist in this line of reasoning as well, however. The first possibility is the most radical: that reanalysis processes allow the parser to settle on a structure that is unlicensed by the principles of human syntax. In effect, two incompatible structures are merged into one—a sort of tree splicing—in which one NP serves as both object/theme of the subordinate clause and subject/agent of the matrix clause. If this could be shown to be the case, it would be a remarkable finding, since it would undermine the most basic assumptions about the nature of the human sentence processor, such as those quoted from Frazier and Clifton (1996) and MacDonald et al. (1994) in the introduction.

A less radical alternative is that the construction of a fully reanalyzed syntactic structure is never completed in that the reanalyzed structure does not match the input string. More specifically, syntactic reanalysis extends over the matrix clause such that the phonetic string *the deer* (in our example) is stolen as the subject of the matrix clause, as described by Fodor and Inoue (1998) (see Fodor & Inoue, 1998, for a detailed discussion). However, the reanalysis terminates at this point (for structurally determined reasons discussed in Fodor and Inoue), leaving the subordinate clause untouched, i.e., with an empty argument node (former site of *the deer*) that is still receiving a thematic role from the subordinate verb, which does not undergo lexical reanalysis from transitive to intransitive. The stolen phonetic material in the matrix clause (*the deer*)

then generates its own syntactic structure and is assigned its own thematic role of agent. In effect, then, one ''copy'' of *the deer* remains in the object position of the subordinate clause (minus its phonetic content), while a second ''copy'' of it (with phonetic content) now occupies the subject position in the matrix clause. The reanalysis, then, is good enough to take care of the severe syntactic problem posed by the subjectless verb and create a licit structure, but not good enough to lead to the construction of a syntactic representation and global interpretation for the entire sentence that are consistent with the input string (Ferreira & Henderson, 1999).

The results reported here are also newsworthy because they link up with several areas of psycholinguistics and cognitive science suggesting that cognitive systems often thought to produce complete and detailed representations in fact do not; instead, they produce representations that are ''good enough'' but not necessarily entirely consistent with the input. We consider it an important advance when literatures from related, adjacent fields are connected and when it is discovered that similar principles apply across different domains of language processing and cognitive science in general. So although our contention that our results here are based on incomplete, syntactically unlicensed reanalyses may seem radical from the perspective of current models of sentence comprehension, it is not without precedent in related literatures. We proceed next to a discussion of some of this work.

The notion that cognitive systems might not always create detailed and complete representations has received some attention in the last few years, but largely from researchers in visual cognition rather than psycholinguistics. The classic view in visual perception has been that the goal of vision is to create a veridical representation of the field of view, which can then support a variety of behavioral competencies relying on vision (e.g., Marr, 1982; Feldman, 1985). However, a large and growing literature has demonstrated that the visual system does not construct a global image of a visual scene (for reviews, see Irwin, 1996; Simons & Levin, 1997; Henderson & Hollingworth, 1999a). Participants are often insensitive to rather large changes in a scene if those changes are made during a saccadic eye movement or other visual disruption, a result that has been termed *change blindness*. For example, if viewers are examining a photograph of two wedding guests, they only occasionally notice when the guests' hats are switched (Grimes, 1996). Detection is more likely if a change is made while the viewer's eyes are moving toward the critical object (Henderson & Hollingworth, 1999b) and if the object is interesting in some way (e.g., anomalous with respect to the scene) (Hollingworth & Henderson, 2000). Researchers in visual cognition have concluded from these results that the visual system is not designed to construct veridical representations of visual scenes.

The field of psycholinguistics has not had its assumption of rich, complete representations challenged in the same systematic way, but phenomena have long existed that indicate the ''good enough'' quality of linguistic representa-

tions. As noted by Clark and Clark (1977), Fillenbaum (1971, 1974) demonstrated that comprehenders tend to ''normalize'' strange sentences. Given a sentence such as *Don't print that or I won't sue you* they paraphrase it as ''If you print that I'll sue you.'' The Moses Illusion (Erickson & Mattson, 1981; Kamas, Reder, & Ayers, 1996) makes a similar point. When readers are asked *How many animals of each type did Moses take on the ark* they reply two and overlook the presence of Moses rather than Noah in the question. The phenomenon of selective processing (Barton & Sanford, 1993; Sanford, 1999) is similar; readers overlook the anomaly in a sentence such as *After the plane crash, the authorities were trying to decide where to bury the survivors*.

More recently, Ferreira and Stacey (submitted) have conducted broadly related studies designed to examine the conditions under which people misinterpret sentences based on their semantic content and syntactic form. Participants listened to sentences such as those shown in (14):

(14a) *The dog bit the man*.
(14b) *The man bit the dog*.
(14c) *The man was bitten by the dog*.
(14d) *The dog was bitten by the man*.

Various tasks were used to assess comprehenders' interpretations of these sentences, and all point to the same conclusion: If the sentence is syntactically more demanding and describes an implausible event [as in (14d)], listeners tend to misinterpret the sentence, normalizing it so that it conforms to the more expected meaning. It is particularly striking that this result holds for a structure like the passive, which is less common than the active but hardly exotic.

The results of the current study also make contact with research on discourse comprehension. Interpretations established early in a discourse but later falsified are often not eliminated from the representation of the entire text (Anderson, Lepper, & Ross, 1980; Johnson & Seifert, 1994; Ross, Lepper, & Hubbard, 1975; Schul & Bernstein, 1985; Thompson, Fong, & Rosenhan, 1981; Wilkes & Leatherbarrow, 1988). For example, Johnson and Seifert (1998) presented readers with stories containing reference terms whose antecedents had to be corrected. They found less activation for the correct referents when the antecedent had to be revised compared to a condition in which the antecedent was consistently correct throughout the story. They concluded that the effect of the misinformation was not completely eliminated after correction—the misinterpretation lingers.

Another intriguing implication of the findings reported in the present experiments is that inhibition processes might play a more important role in sentence comprehension than has hitherto been assumed. Indeed, Johnson and Seifert (1998) discuss this issue in their work on suppression of misinformation in text comprehension. They note that some work on text comprehension suggests that information that is no longer relevant can be effectively inhibited or suppressed (Gernsbacher & Faust, 1991; Hasher, Quig, & May,

1997). Johnson and Seifert argue that their work is compatible with the assumption that inhibition of information must sometimes take place, but they take issue with the notion that the suppression is always successful. In the field of sentence comprehension, it has not been generally assumed that any sort of inhibition processes play a major role, and so discussion has not yet progressed to the point of considering whether suppression is always or just sometimes successful. For example, Dagenbach and Carr (1994) reviewed work on inhibition in cognitive processing, including language. Yet, their review did not discuss the possibility that inhibition plays a role in sentence comprehension beyond the phonological and lexical levels (that is, for syntactic or propositional units). The results of our experiments suggest that models of sentence comprehension and parsing that do not include a role for inhibition are incomplete. It appears that the system must be able both to maintain correct interpretations and suppress ones that are inappropriate. How and under what conditions the inhibition operates is an almost entirely unexplored question in psycholinguistics.

Finally, the results of these experiments have a clear, methodological moral as well: Not all comprehension questions will be equally capable of revealing whether the participants have in fact truly understood the garden path sentences presented to them in an experiment. For example, if we had conducted a more typical study of garden path effects in comprehension, we might have given participants the materials from, say, Experiment 2 (e.g., *As Harry chewed the steak that was brown and juicy fell to the floor*) and focused on strictly online measures. To ensure that the sentences were understood, we might have asked the participants fairly superficial comprehension questions such as, *Was the steak juicy*? Our results suggest that the participants would be quite likely to answer that question correctly. Furthermore, they could have even answered quite well a question that tapped into the extent to which they had comprehended the correct structure—viz. *Did the steak fall to the floor?* From this result, we might have concluded that the sentences were correctly interpreted. However, what our full set of results reveals is that the critical, distinguishing question is not either of these: It is an item such as *Did Harry chew the steak?* It is this latter question which reveals that the sentences were not entirely understood. The implication, then, is that studies of garden pathing which assume that participants do compute the ultimately correct structure and interpretation should include in their reports more compelling evidence that this level of understanding indeed was achieved. If it turns out that it was not, then doubts are raised about whether the representations for the sentences presented to participants were rich, complete, and accurate.

CONCLUSION

People often do not fully comprehend garden path sentences of the variety we examined here: those involving a subordinate and main clause together

with an NP that attaches initially to the former but ultimately to the latter. Our results show that the main clause is reanalyzed to give the disambiguating verb an appropriate subject. The next step in reanalysis should be to alter the interpretation of the subordinate clause so as not to include that NP. Our experiments demonstrate that this step is not always taken, leaving the comprehender with a global interpretation in which some version of the NP (either two ''copies'' thereof or one shared by both clauses) serves at least semantically as the subject of the main clause and the object of the subordinate clause simultaneously. This phenomenon of incomplete reanalysis suggests that comprehension is not always geared toward the creation of the precise structure present in the sentence, but rather often has a ''good enough'' flavor (Ferreira & Henderson, 1999): The interpretation of the sentence seems fine to the comprehender (even though in reality it is unlicensed by the input), and so he or she judges that processing has been successful and that further operations are not necessary. This heretofore undiscovered tendency emerged when we seriously probed the interpretations comprehenders obtained for these utterances. Therefore, a great deal can be learned from comprehension measures as well as from the more online measures such as eye movement monitoring that have been de rigueur over the past 20 years in psycholinguistics.

APPENDIX 1

Materials for Experiments 1a, 1b, and 2

The first *list* contains the experimental sentences for Experiments 1a and 1b. The scheme for converting these items into the experimental conditions can be inferred from Table 1. Experiment 2 used the same set of sentences but with two modifications: clause order (which can be derived from sentences below) and head position (which can also be derived from the relative clauses below, e.g., *the deer that was brown and graceful* → *the brown and graceful deer*). In addition, Experiment 2 included a question probing the matrix clause (second list below). Finally, items 41 and 42 were omitted from Experiment 2.

Experimental sentences for Experiments 1a and 1b

1. While the man hunted (the pheasant) the deer (that was brown and graceful) *ran into the woods*/*paced in the zoo*
   Did the man hunt the deer?
2. While the skipper sailed (the ship) the boat (that was small and leaky) *veered off course*/*remained at the dock*
   Did the skipper sail the boat?
3. While the reporter photographed (the astronaut) the rocket (that was silver and white) *sat on the launch pad*/*landed on Mars*
   Did the reporter photograph the rocket?
4. While the orchestra performed (the concerto) the symphony (that was short and simple) *played on the radio*/*played on the phonograph*
   Did the orchestra perform the symphony?
5. While the student read (the magazine) the notes (that were long and boring) *blew off the desk*/*burned in the fireplace*
   Did the student read the notes?
6. While Jack ordered (the pizza) the fish (that was silver and black) *cooked in a pot*/

swam upstream
Did Jack order the fish?

7. While Susan wrote (the note) the letter (that was long and eloquent) *fell off the table*/*arrived from Paris*
   Did Susan write the letter?
8. While the secretary typed (the letter) the memo (that was clear and concise) *neared completion*/*arrived in the mail*
   Did the secretary type the memo?
9. While the farmer steered (the golf cart) the tractor (that was big and green) *pulled the plough*/*lay in a ditch*
   Did the farmer steer the tractor?
10. While the lawyer studied (the will) the contract (that was old and wrinkled) *lay on the roll-top desk*/*remained in the safety deposit box*
    Did the lawyer study the contract?
11. As Henry whittled (the log) the stick (that was long and bumpy) *broke in half*/*burned in the campfire*
    Did Henry whittle the stick?
12. While Rick drove (the truck) the car (that was red and dusty) *veered into a ditch*/*warmed up in the garage*
    Did Rick drive the car?
13. As the mare fed (the yearling) the colt (that was young and black) *stamped its hoof*/*raced in the field*
    Did the mare feed the colt?
14. While the clown juggled (the apples) the balls (that were bright and colorful) *fell on the ground*/*sat on the table*
    Did the clown juggle the balls?
15. As the man walked (the collie) the poodle (that was small and gray) *barked loudly*/*whimpered in the city pound*
    Did the man walk the poodle?
16. As Mark vacuumed (the carpet) the drapes (that were white and pleated) *hung in the window*/*spun in the dryer*
    Did Mark vacuum the drapes?
17. As the explorer paddled (the raft) the canoe (that was long and narrow) *headed toward a waterfall*/*rotted on the river bank*
    Did the explorer paddle the canoe?
18. As the cowboy rode (the bull) the horse (that was big and strong) *sweated profusely*/*slept peacefully*
    Did the cowboy ride the horse?
19. While Tom grilled (the hamburger) the hot dog (that was long and fatty) *began to burn*/*cooled in the fridge*
    Did Tom grill the hot dog?
20. While the caricaturist drew (the dog) the child (that was freckled and talkative) *stood on the sidewalk*/*watched a movie*
    Did the caricaturist draw the child?
21. While the chef stirred (the sauce) the soup (that was spicy and tasty) *boiled over*/*thawed on the counter*
    Did the chef stir the soup?
22. While the scientists explored (the island) the cave (that was dark and damp) *grew cold*/*remained undiscovered*
    Did the scientists explore the cave?
23. While the woman drank (the beer) the water (that was clear and cold) *spilled on the floor*/*overflowed from the toilet*
    Did the woman drink the water?
24. While the snake swallowed (the mouse) the frog (that was green and spotted) *kicked*

vigorously/*jumped into the pond*
Did the snake swallow the frog?

25. As the lion attacked (the gazelle) the baboon (that was short and hairy) *screamed in terror*/*watched from its cage*
Did the lion attack the baboon?
26. As the maid dusted (the coffee table) the picture (that was black and white) *tipped over*/*developed in the dark room*
Did the maid dust the picture?
27. While Sam counted (the cars) the children (that were small and unruly) *boarded the bus*/*failed to arrive*
Did Sam count the children?
28. As the champion raced (the coach) the challenger (that was strong and fast) *stumbled and fell*/*watched from the sidelines*
Did the champion race the challenger?
29. As Jerry played (the piano) the violin (that was old and dingy) *went out of tune*/*gathered dust in the attic*
Did Jerry play the violin?
30. As the artist painted (the landscape) the model (that was tall and thin) *sat in the chair*/*went out for lunch*
Did the artist paint the model?
31. While Kendra parked (the bus) the van (that was brown and green) *bumped the curb*/*rusted in the junkyard*
Did Kendra park the van?
32. As Angela cleaned (the oven) the dog (that was spotted and black) *stood in the yard*/*ran down the street*
Did Angela clean the dog?
33. While the sailor smoked (the cigar) the pipe (that was old and smelly) *glowed brightly*/*remained unlit*
Did the sailor smoke the pipe?
34. While the director filmed (the extras) the actor (that was rich and famous) *recited the lines*/*took a break*
Did the director film the actor?
35. As the athlete wrestled (the teammate) the opponent (that was large and sweaty) *shouted insults*/*arrived at the gym*
Did the athlete wrestle the opponent?
36. While the warrior fought (the bear) the enemy (that was cold and hungry) *retreated*/*slept soundly*
Did the warrior fight the enemy?
37. As Harry chewed (the apple) the steak (that was brown and juicy) *fell to the floor*/*thawed on the counter*
Did Harry chew the steak?
38. While the puppy sniffed (the baby) the kitten (that was fluffy and white) *sat on the sofa*/*remained lost*
Did the puppy sniff the kitten?
39. As Bill ate (the ham) the turkey (that was plump and brown) *sat on the table*/*pecked at the corn*
Did Bill eat the turkey
40. While Janet baked (the pie) the bread (that was wholesome and delicious) *rose in the oven*/*grew moldy*
Did Janet bake the bread?
41. As the detective investigated (the murder) the robbery (that was surprising and brutal) *caused panic*/*occurred*
Did the detective investigate the robbery?

42. As the professor lectured (the parents) the students (that were young and nervous) *took notes*/*drove home*
    Did the professor lecture the students?

Matrix clause questions for Experiment 2

1. Did the deer run into the woods?
2. Did the boat veer off course?
3. Did the rocket sit on the launch pad?
4. Did the symphony play on the radio?
5. Did the notes blow off the desk?
6. Did the fish cook in the pot?
7. Did the letter fall off the table?
8. Did the memo near completion?
9. Did the tractor pull the plough?
10. Did the contract lie on the roll-top desk?
11. Did the stick break in half?
12. Did the car veer into a ditch?
13. Did the colt stamp its hoof?
14. Did the balls fall on the ground?
15. Did the poodle bark loudly?
16. Did the drapes hang in the window?
17. Did the canoe head toward a waterfall?
18. Did the horse sweat profusely?
19. Did the hot dog begin to burn?
20. Did the child stand on the sidewalk?
21. Did the soup boil over?
22. Did the cave grow cold?
23. Did the water spill on the floor?
24. Did the frog kick vigorously?
25. Did the baboon scream in terror?
26. Did the picture tip over?
27. Did the children board the bus?
28. Did the challenger stumble and fall?
29. Did the violin go out of tune?
30. Did the model sit in the chair?
31. Did the van bump the curb?
32. Did the dog stand in the yard?
33. Did the pipe glow brightly?
34. Did the actor recite the lines?
35. Did the opponent shout insults?
36. Did the enemy retreat?
37. Did the steak fall to the floor?
38. Did the kitten sit on the sofa?
39. Did the turkey sit on the table?
40. Did the bread rise in the oven?

APPENDIX 2

Materials for Experiments 3a and 3b

Below are listed the sentences involving Reflexive Absolute Transitive verbs and the corresponding questions. The sentences with optionally transitive verbs were items 1–12 from Appendix 1.

1. While Jim bathed the child that was blond and pudgy giggled with delight
   The child that was blond and pudgy giggled with delight while Jim bathed
   Did Jim bathe the child?
2. While the chimps groomed the baboons that were large and hairy sat in the grass
   The baboons that were large and hairy sat in the grass while the chimps groomed
   Did the chimps groom the baboons?
3. While Frank dried off the car that was red and shiny sat in the driveway
   The car that was red and shiny sat in the driveway while Frank dried off
   Did Frank dry off the car?
4. While Betty woke up the neighbor that was old and cranky coughed loudly
   The neighbor that was old and cranky coughed loudly while Betty woke up
   Did Betty wake up the neighbor?
5. While the thief hid the jewelry that was elegant and expensive sparkled brightly
   The jewelry that was elegant and expensive sparkled brightly while the thief hid
   Did the thief hide the jewelry?
6. While Anna dressed the baby that was small and cute spit up on the bed
   The baby that was small and cute spit up on the bed while Anna dressed
   Did Anna dress the baby?
7. While the boy washed the dog that was white and furry barked loudly
   The dog that was white and furry barked loudly while the boy washed
   Did the boy wash the dog?
8. While the jockey settled down the horse that was sleek and brown stood in the stall
   The horse that was sleek and brown stood in the stall while the jockey settled down
   Did the jockey settle down the horse?
9. While the mother undressed the baby that was bald and helpless cried softly
   The baby that was bald and helpless cried softly while the mother undressed
   Did the mother undress the baby?
10. While the nurse shaved the patient that was tired and weak watched TV
    The patient that was tired and weak watched TV while the nurse shaved
    Did the nurse shave the patient?
11. While the girl scratched the cat that was gray and white stared at the dog
    The cat that was gray and white stared at the dog while the girl scratched
    Did the girl scratch the cat?
12. While the mother calmed down the children that were tired and irritable sat on the bed
    The children that were tired and irritable sat on the bed while the mother calmed down
    Did the mother calm down the children?

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