The influence of *only* on syntactic processing of “long” relative clause sentences

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We report an eye movement experiment investigating the influence of the focus operator *only* on syntactic processing of “long” relative clause sentences. Paterson, Liversedge, and Underwood (1999) found that readers were garden pathed by “short” reduced relative clause sentences containing the focus operator *only*. They argued that due to thematic differences between “short” and “long” relative clause sentences, garden path effect might not occur when “long” reduced relative clause sentences are read. Eye-tracking data show that garden path effects found during initial processing of the disambiguating verb of “long” reduced sentences without *only* were absent or delayed in the case of counterparts with *only*. We discuss our results in terms of current theories of sentence processing.

A central issue in syntactic processing research is whether initial parsing decisions are made using syntactic knowledge alone or are influenced by higher order factors such as referential properties of the reader’s discourse model. “Restricted” theories (Traxler & Pickering, 1996) require that syntactic knowledge alone dictates initial processing of ambiguous sentences like (1) and (2):

1. The spy shot the cop with the ginger hair.  
2. The florist sent the flowers smiled.

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For instance, Garden path theory (Frazier, 1979) requires that initial parsing decisions follow principles of minimal attachment and late closure and are not influenced by referential context. However, the referential theory (Crain & Steedman, 1985) stipulates that prior referential context can prevent a reader from initially misanalysing syntactically ambiguous sentences. Crain and Steedman suggested that if context contains two possible referents of a definite noun phrase from an ambiguous sentence, then whenever possible, ambiguous portions of the sentence will be processed as information specifying which one is the referent. Thus, when Sentence 1 follows a context containing two cops, readers should attach the prepositional phrase low to the cop, and when Sentence 2 follows a context containing two florists, readers initially should process it as a reduced relative. In each case the ambiguous phrase is treated as a modifier that disambiguates a referential association.

However, when syntactically ambiguous sentences are read in isolation, the principle of parsimony applies, and the reader constructs a discourse representation containing fewest referential presuppositions. Consequently, readers instantiate a discourse representation containing one referent of each definite noun phrase. As there is no ambiguity concerning the referent of the noun phrase, readers do not anticipate further modifying information. Therefore, in (1) the ambiguous phrase is attached high to the verb, and in (2) the ambiguous verb is processed as a simple active rather than a relative clause. At disambiguation (ginger hair; smiled), readers detect their initial mianalysis and initiate reanalysis.

Several studies have demonstrated the influence of referential context on parsing of various types of syntactically ambiguous sentence (Altmann, Garnham, & Dennis, 1992; Altmann, Garnham, & Henstra, 1992; Altmann & Steedman, 1988; Britt, 1994; Britt, Perfetti, Garrod, & Rayner, 1992; Clifton & Ferreira, 1989; Ferreira & Clifton, 1986; Mitchell, Corley, & Garnham, 1992; Murray & Liversedge, 1994; Rayner, Garrod, & Perfetti, 1992; Spivey-Knowlton, Trueswell, & Tanenhaus, 1993; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995; Trueswell & Tanenhaus, 1991). More recent studies manipulated referential properties of the discourse model by inclusion of a focus operator (Clifton, Bock, & Rado, 2000; Ni, Crain, & Shankweiler, 1996; Paterson, Liversedge, & Underwood, 1999). Consider Sentence 3:

3. Only horses raced past the barn fell.

Ni et al. (1996) argued that only causes readers to construct discourse models in which an element in focus (i.e., a set of horses) is contrasted with a set of alternatives. As the contrast set is not made explicit readers must infer one. Readers may either contrast a focus set of horses with another set of entities, or contrast two sets of horses. Ni et al. argue that the principle of parsimony requires readers to initially opt for the latter option as it incorporates fewer referential presuppositions. Having instantiated two sets of the same kind, readers anticipate information that distinguishes between them. Consequently, for Sentence 3 the clause raced past the barn initially should be processed as modifying horses, thus eliminating garden path effects associated with reduced relative clause sentences. In an eye tracking study, Ni et al. found that subjects read sentences like (3) without difficulty.

However, Clifton et al. (2000) and Paterson et al. (1999) challenged these results. Clifton et al. reported an eye tracking study in which readers experienced difficulty for reduced relative clause sentences with and without only. Furthermore, Paterson et al. argued that Ni et al.
(1996) obtained the effects they did because their materials included qualitatively different types of relative clause sentence. Consider Fragment 4 and Sentences 5–8:

4. The men passed . . .
5. The men passed the salt.
6. The men passed the salt smiled.
7. The men passed in the car.
8. The men passed in the car waved.

Fragment 4 could be part of a simple active sentence (e.g., 5 or 7), or reduced relative clause sentence (e.g., 6 or 8). In (5) the ambiguous verb is followed by a noun phrase (the salt), which can be taken as a direct object. In (7) a prepositional phrase follows the verb and rules out a direct object construction. For such sentences, the reader may adopt a simple active reading without a direct object, or pursue a relative clause analysis. For example, the addition of smiled in (6) or waved in (8) converts these from simple active to reduced relative clause sentences. Paterson et al. (1999) termed sentences like (6), without a noun phrase, verb, noun phrase construction, “short” relative clause sentences (see also Murray & Liversedge, 1994), in contrast to “long” relative clause sentences like (8), in which a prepositional phrase follows the verb.1

Paterson et al. (1999) argued that only would not influence parsing of “short” relative clause sentences as readers are strongly predisposed to process noun phrase, verb, noun phrase fragments as direct object sentences due to a strong subject, verb, object (SVO) preference. Such a preference is in line with the canonical sentoid strategy (Bever, 1970). However, Paterson et al. suggested that only may influence initial parsing of “long” reduced relative clauses as the prepositional phrase rules out the preferred direct object analysis, leaving the parser to select between dispreferred simple active (without direct object) and relative clause analyses. In this case, referential factors might guide the selection of an initial analysis. Paterson et al. reported an eye tracking study in which only did not influence initial parsing of “short” relative clause sentences, but facilitated reanalysis. They argued that these results were incompatible with referential theory, but consistent with restricted theories, or with constraint-based theories considered as follows.

Advocates of constraint-based approaches (MacDonald, 1994; MacDonald, Peralmutter, & Seidenberg, 1994a, b; Peralmutter & MacDonald, 1992; Spivey-Knowlton et al., 1993; Spivey-Knowlton & Sedivy, 1994; Tabossi, Spivey-Knowlton, McRae, & Tanenhaus, 1994; Trueswell, Tanenhaus, & Garnsey, 1994; Trueswell, Tanenhaus, & Kello, 1993) claim that multiple sources of information constrain the parsing process, including knowledge about referential context. At each point in the sentence, there is competition between syntactic analyses

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1Note that the terms “long” and “short” do not refer to the length of a sentence in terms of number of words or characters, but instead are used simply as convenient labels to distinguish between sentences with a noun phrase (NP), verb (V), NP structure and sentences with a NP, V, propositional phrase (PP) structure. On average our NP, V, PP sentences did contain more words than our NP, V, NP sentences (though this need not necessarily have been the case). Furthermore, our labelling is consistent with the terminology employed in other publications (e.g., Murray & Liversedge, 1994; Paterson, Liversedge, & Underwood, 1999). We also note that MacDonald (1994), used the terms “DO-phrase” to refer to the second NP in a NP, V, NP structure and “not-DO phrase” to refer to the PP as part of a NP, V, NP structure, respectively.
favoured by constraints imposed thus far, and garden path effects occur when a constituent is encountered that conflicts with the previously favoured analysis.

MacDonald (1994) argues thematic information associated with verbs that are ambiguous between reduced relative/main clause analyses is one source of constraint on parsing. Her predictions match those made by Paterson et al.’s (1999) about processing of “short” and “long” relative clause sentences. MacDonald argues that thematic structures associated with main verb and relative clause analyses become activated as a function of their frequency in the language and compatibility with other sentential information. A direct object analysis may be pursued when a noun phrase immediately follows the ambiguous verb (with the strength of preference for this analysis depending on verb transitivity). If a prepositional phrase follows the verb, it rules out a direct object reading and favours analyses with different argument structures (e.g., reduced relative clause or active intransitive analyses).

Constraint-based theorists have claimed that constraint strengths can be quantified using off-line methodologies such as sentence completion studies to generate predictions about reading times. In these studies sentence fragment completions consistent with possible syntactic analyses are interpreted as a measure of the strength of constraint in favour of that analysis at that point in the sentence (Spivey-Knowlton & Sedivy, 1994). We adopted sentence completion methodology to generate constraint-based predictions for the current study (see Method).

In this study we compared parsing of reduced “long” relative clause sentences with or without only (e.g., Sentence 9) against unreduced counterparts.

9. The/Only motorists stopped in the car park received a warning about their outdated permits.

We can make four contrasting theoretical predictions. First, restricted accounts predict readers will be garden pathed by the disambiguating verb of reduced sentences, regardless of only. Second, according to Ni et al.’s (1996) version of referential theory, subjects should be garden pathed by reduced sentences without only, but not by counterparts with only. Third, Paterson et al. (1999) argue that although only does not influence initial parsing for “short” reduced sentences due to a strong SVO preference, it may influence initial parsing of “long” reduced sentences as an SVO analysis is not available. Hence, subjects should be garden pathed by “long” reduced sentences without only, but not by counterparts with only. Finally, according to constraint-based theories parsing decisions at the disambiguating verb reflect the outcome of competition between constraints imposed at this point in the sentence. Data obtained in sentence-completion tasks will therefore predict the pattern of reading times that we might anticipate. For this reason, we conducted a sentence completion experiment to generate constraint-based predictions before conducting the eye tracking experiment.

**EXPERIMENT**

**Method**

**Subjects**

A total of 32 native English-speaking participants from the University of Durham with normal or corrected vision were paid £4.
Materials and design

We constructed 32 sets of reduced and unreduced items with and without only (see Appendix). Items were placed in one of four lists to be used in the eye tracking experiments. Each list contained 8 items of each form with 49 filler items of various constructions. Each item appeared once in a list. Item forms were rotated across lists following a Latin square design. We collected sentence completions for fragments of “short” relative clause sentences used by Paterson et al. (1999) and fragments of “long” relative clause sentences used in the present experiment. The inclusion of these sentence fragments provides a valuable opportunity to map the pattern of completions for “short” relative clause fragments directly onto the reading times reported by Paterson et al. On the basis of the relationship between the completion data and the reading times obtained for the “short” relative clause stimuli, we should obtain a clear indication of what to expect in terms of reading time differences for the “long” relative clause sentences. Thus, we should be able to form predictions about reading time differences that the constraint-based processor would make for the “long” relative clause sentences with and without only.

A total of 36 subjects from University of Durham (who did not participate in the eye tracking study) took part. Of these, 18 completed lists of fillers and “short” fragments created by truncating the Paterson et al. (1999) materials after the ambiguous phrase: for example, The/Only teenagers allowed a party. . . . The remaining subjects completed lists of fillers and “long” relative clause fragments from the current eye tracking study truncated after the prepositional phrase: for example, The/Only motorists stopped in the car park. . . . Mean percentage of relative clause completions for “long” and “short” fragments with and without only are given in Table 1. We analysed completion data using two 2(fragment type) × 2(determiner) analyses of variance (ANOVAs). The main effect of determiner was significant, \( F_1(1, 34) = 24.42, p < .01; F_2(1, 66) = 29.66, p < .01 \), with more relative clause completions for fragments with only. The difference in relative clause completions for “long” and “short” fragments was not reliable, \( F_1 < 1; F_2(1, 66) = 1.6, p < .05 \). The interaction of fragment type and determiner was significant by subjects and marginal by items, \( F_1(1, 34) = 4.41, p < .05; F_1(1, 66) = 3.46, p < .07 \). The proportion of relative clause completions was equivalent for “short” and “long” fragments without only, \( F_s < 1 \). However, there were more relative clause completions for “short” fragments with only than for those without only, \( F_1(1, 34) = 9.41, p < .01 \), and for “long” fragments with only than for those without only, \( F_1(1, 34) = 21.44, p < .001 \), and \( F_2(1, 33) = 21.58, p < .001 \). The size of the effect for “short” fragments was two and a half times that observed for “long” fragments. According to the completion data, the focus operator provided a weaker constraint for the “long” sentences than for the “short” sentences. Paterson et al. (1999) observed clear garden path effects for “short” sentences; consequently, the constraint-based theory predicts garden path effects for long relative clause sentences regardless of only.

<table>
<thead>
<tr>
<th></th>
<th>Short</th>
<th>Long</th>
</tr>
</thead>
<tbody>
<tr>
<td>The</td>
<td>9.6</td>
<td>9.2</td>
</tr>
<tr>
<td>Only</td>
<td>26.3</td>
<td>15.9</td>
</tr>
</tbody>
</table>
Procedure

A Fourward Technologies Dual Purkinje Image Generation 5.5 eye-tracker monitored gaze location and movement of subjects' right eye. The tracker has an angular resolution of 10' arc. A PC displayed materials on a VDU positioned 80 cm from subjects' eyes. Gaze location was sampled every millisecond and output as a sequence of fixations with x and y character positions and start and finish times.

Subjects were run individually. Before the experiment began, they read instructions explaining the eye tracking procedure and were asked to read normally and for comprehension. A bite bar and forehead restraint minimized head movements. Subjects completed a calibration procedure. After a successful calibration the sentences were presented in two blocks. Calibration was checked before each trial.

Each experiment list was presented to subjects in fixed random order. Sentences were presented double-spaced on one or two lines, depending on length. After completing reading a sentence, subjects pressed a key on a response box. After 32 items a comprehension question was presented, and subjects answered with a key press, with feedback on answers. Half of the questions required a "Yes" response. In total the experiment took about 30 min.

Results

Regions

Sentences were divided into six scoring regions indicated by vertical lines in Sentence 10. Region 1 contained the initial noun phrase. The phrase who were in unreduced conditions was excluded from analyses.

10. Only/The motorists (who were) | stopped | in the car park | received | a warning about | their outdated permits.

Region 2 contained the ambiguous verb, Region 3 contained the prepositional phrase, and Region 4 contained the disambiguating verb. Region 5 was a post-critical region (two or three words), and Region 6 was the final region comprising the remainder of the sentence (see Appendix for segmentation).

Analyses

Automatic procedures pooled short contiguous fixations as follows: Fixations of less than 80 ms were incorporated into larger adjacent fixations within one character, and fixations of less than 40 ms that were not within three characters of another fixation were deleted. Prior to the analysis of eye movement data, trials were removed where subjects failed to read the sentence or where there had been tracker loss (i.e., trials in which two or more adjacent regions had zero first-pass reading times). This accounted for 3.7% of data. We also examined responses to comprehension questions, with correct responses on 97.1% of occasions.

The following were computed: (1) First pass reading time, which was the sum of fixations made after first entering a region before a fixation to the left or right of this region;2 (2) total

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2We also examined first fixation duration in the disambiguating region to ensure that we did not miss early short-lived garden path effects. These data showed a similar pattern to first pass reading times for this region and are therefore omitted.
reading time, the sum of all fixations made in a region; and (3) first pass regressions from the critical region, defined as any saccade initiated from a first pass fixation that transgressed the left boundary of a region. Re-reading times for Regions 4 and 5 were also computed. Re-reading time is the sum of fixations following a first pass regression from a region until a fixation is made to the right of that region (regression path time minus first pass reading time for that regression, Liversedge, Paterson, & Pickering, 1998). Paterson et al. (1999; see also Liversedge et al., 1998) used this measure to determine time spent re-inspecting text after an initial misanalysis. Finally, we computed sentence-completion reading times, defined as the sum of fixations following a saccade that terminates re-reading time for a region until the subject completes reading the sentence. This measure enabled us to investigate whether there was a delayed garden path effect for reduced sentences with only.

Data for each region were subjected to two $2$ (determiner) × $2$ (sentence structure) ANOVAs. Mean first pass reading times, total reading times, and percentage first pass regressions are given in Table 2.

### First pass reading time

At Region 2 first pass reading times were longer for reduced than unreduced sentences, $F_1(1, 31) = 27.74, p < .001$, and $F_2(1, 31) = 37.56, p < .001$. An effect of determiner was significant by items alone, $F_1(1, 31) = 2.40, p > .05$, and $F_2(1, 31) = 4.25, p < .05$, with longer reading times for sentences without only. There was no interaction between determiner and sentence structure, $Fs < 1$. No main effects of determiner or sentence structure were found at Region 3, $Fs < 1$, and there was no interaction of the two, $F_1(1, 31) = 2.07, p > .05$, and $F_2(1, 31) = 2.36,$

### Table 2

<table>
<thead>
<tr>
<th>Regions</th>
<th>Measure</th>
<th>The Reduced</th>
<th>The Unreduced</th>
<th>Only Reduced</th>
<th>Only Unreduced</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SE$</td>
<td>$M$</td>
<td>$SE$</td>
<td>$M$</td>
</tr>
<tr>
<td>2 “stopped”</td>
<td>First pass reading time</td>
<td>295</td>
<td>12.2</td>
<td>250</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>Total reading time</td>
<td>461</td>
<td>28.3</td>
<td>369</td>
<td>18.6</td>
</tr>
<tr>
<td>3 “in the car park”</td>
<td>First pass reading time</td>
<td>621</td>
<td>29.7</td>
<td>646</td>
<td>29.3</td>
</tr>
<tr>
<td></td>
<td>Total reading time</td>
<td>927</td>
<td>63.4</td>
<td>858</td>
<td>51.5</td>
</tr>
<tr>
<td>4 “received”</td>
<td>First pass reading time</td>
<td>324</td>
<td>17.5</td>
<td>317</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>First pass regions</td>
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<td>9.4</td>
<td>10.2</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>Total reading time</td>
<td>455</td>
<td>29.7</td>
<td>400</td>
<td>19.0</td>
</tr>
<tr>
<td>5 “a warning about”</td>
<td>First pass reading time</td>
<td>492</td>
<td>29.3</td>
<td>462</td>
<td>28.9</td>
</tr>
<tr>
<td></td>
<td>Total reading time</td>
<td>637</td>
<td>40.5</td>
<td>636</td>
<td>36.7</td>
</tr>
</tbody>
</table>

$^a$In percentages.

$^b$In ms.
p > .05. No significant main effects or interaction were found at Region 4, the disambiguating verb, $F_s > 1$, or at Region 5, $F_s < 2.54$. Unlike the Paterson et al. (1999) study, first pass reading time data showed no evidence of garden path effects.

**First pass regressions**

At Region 4, the main effect of determiner was significant in the subject analysis and approached significance in the item analysis, $F_1(1, 31) = 4.58, p < .05$, and $F_2(1, 31) = 3.52, p < .07$. Subjects made more regressions from Region 4 of sentences without only. There was a significant effect of sentence structure, with more regressions from reduced sentences, $F_1(1, 31) = 5.63, p < .05$, and $F_2(1, 31) = 7.62, p < .05$. Crucially, there was a significant interaction of sentence structure and determiner, $F_1(1, 31) = 4.10, p < .05$, and $F_2(1, 31) = 6.29, p < .05$. Subjects made more regressions from the critical region of reduced sentences than from unreduced sentences without only, $F_1(1, 31) = 7.61, p < .01$, and $F_2(1, 31) = 11.67, p < .01$. The number of regressions for reduced and unreduced sentences with only did not differ, $F_s < 1$. Assuming that first pass regressions provide an index of disruption to initial processing, then disruption occurred at syntactic disambiguation for reduced sentences without only but not for those with only.

**Total reading times**

At Region 2 there was an effect of sentence structure, $F_1(1, 31) = 26.54, p < .001$, and $F_2(1, 31) = 45.11, p < .001$, with longer reading times for reduced sentences, but no effect of determiner or interaction of determiner and sentence structure, $F_s < 1$. At Region 3 there was an effect of sentence structure, $F_1(1, 31) = 8.54, p < .05$, and $F_2(1, 31) = 12.90, p < .01$, with longer reading times for reduced sentences, but no significant effects of determiner or interaction of sentence structure and determiner, $F_s < 1.15$. At Region 4, there were no significant effects of determiner or interaction of sentence structure and determiner, $F_s < 1.1$. The main effect of sentence structure was not reliable, $F_1(1, 31) = 3.75, p > .05$, and $F_2(1, 31) = 20.37, p < .01$. There were no significant effects at Region 5, $F_s < 1.7$. Total reading times for Regions 2 and 3 provided the first indication that readers found reduced sentences more difficult than unreduced sentences regardless of only.

**Re-reading time**

Re-reading times for Regions 4 and 5 and sentence completion reading times for Region 4 are shown in Table 3. At Region 4, re-reading times were longer for reduced than for unreduced sentences, $F_1(1, 31) = 9.80, p < .01$, and $F_2(1, 31) = 22.18, p < .001$. The main effect of determiner was not reliable, $F_1(1, 31) = 2.39, p < .05$, $F_2(1, 31) = 3.72, p < .07$, but the interaction of determiner and sentence structure was significant, $F_1(1, 31) = 5.42, p < .05$, and $F_2(1, 31) = 9.88, p < .01$. Subjects spent longer re-reading reduced than unreduced sentences without only, $F_1 = 14.20, p < .01$, and $F_2 = 26.94, p < .01$. However, re-reading times did not differ for reduced and unreduced sentences with only, $F_s < 1$. Results indicate that subjects spent longer re-reading reduced sentences without only than reduced sentences with only. Longer
re-reading times for reduced sentences without *only* may be due to readers re-inspecting text to recover from initial difficulty.\(^3\)

At Region 5, there were no reliable effects of sentence structure or determiner and no interaction between the two, \(F_s < 2.13\). However, re-reading times for reduced sentences with *only* were numerically longer than those for reduced sentences without *only* or unreduced counterparts. Furthermore, there was a small numerical difference in re-reading times for reduced and unreduced sentences with *only* at Region 4. If combined, these numerical differences might reflect disruption occurring across Regions 4 and 5 of reduced sentences with *only*. We analysed re-reading times for these regions using 2(region) × 2(determiner) × 2(sentence structure) ANOVAs. If disruption occurred across both regions of reduced sentences with *only*, we would expect a main effect of sentence structure and two-way interactions involving region due to disruption at Region 4 for reduced sentences without *only* and disruption at Region 5 for reduced sentences with *only*. We would not expect a three-way interaction of region, determiner, and sentence structure, as this would indicate disruption at Region 4 for reduced sentences without *only* but no disruption at Region 5 for reduced sentences with *only*.

The main effect of region was not reliable, \(F_1(1, 31) = 3.80, p < .07\), and \(F_2(1, 31) = 1.81, p < .05\), and there was no main effect of determiner, \(F_s < 1\). However, re-reading times were longer for reduced than for unreduced sentences, \(F_1(1, 31) = 7.88, p < .01\), and \(F_2(1, 31) = 11.32, p < .01\). There was no two-way interaction of region and sentence structure, \(F_s < 1\), no two-way interaction of sentence structure and determiner, \(F_s < 1\), and no significant two-way

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\(^3\)As we did not include filler items beginning with *only*, it was possible that the focus operator could cue our experimental sentences and cause subjects to adopt unusual strategies. Consequently, we conducted an analysis in which we correlated the magnitude of the interaction for first pass regressions and also rereading times for Region 4 with trial number. We anticipated a significant positive correlation if subjects had learned to use the presence of the focus operator as a cue to the occurrence of relative clause sentences over the course of the experiment. However, there was a non-significant negative correlation between item number and magnitude of interaction for first pass regressions \((r = -.28, p < .05)\), and a significant negative correlation between item number and the magnitude of the interaction for rereading times \((r = -.58, p < .001)\). Results demonstrate that subjects did not adopt a strategy that enabled them to anticipate the occurrence of relative clause sentences.
interaction of region and determiner, $F_1(1, 31) = 3.04, p < .05$, and $F_2(1, 31) = 2.36, p < .05$. The three-way interaction of region, sentence structure, and determiner was significant, $F_1(1, 31) = 4.55, p < .05$, and $F_2(1, 31) = 5.20, p < .05$. Results indicate disruption at Region 4 for reduced sentences without *only*, but no evidence of disruption across Regions 4 and 5 for reduced sentences with *only*.

**Sentence-completion reading times**

Effects found in total reading times but not in measures of first pass reading time or first pass regressions usually are interpreted as reflecting a process that occurred relatively late in comprehension. Although we obtained no indication of disruption in first pass reading times for the disambiguating verb, we did obtain effects on first pass reading times and re-reading times that are consistent with the conclusion that subjects were disrupted when reading reduced sentences without *only*, but not reduced sentences with *only*. However, total reading times indicated that subjects experienced more difficulty in processing reduced than unreduced sentences. Perhaps subjects were garden pathed when they read reduced sentences with *only*, but the effect was delayed relative to that which occurred for reduced sentences without *only*. If so, then disruption of a similar magnitude to that observed for reduced sentences without *only* should have occurred for reduced sentences with *only* at some point after the disambiguating verb. We therefore examined sentence-completion times. Delayed garden path effects should result in longer sentence-completion times for reduced sentences with *only* than for those without *only*.

Sentence-completion reading times showed a main effect of sentence structure, $F_1(1, 31) = 15.74, p < .001$, and $F_2(1, 31) = 13.73, p < .01$, with more time taken for reduced sentences. There was no significant main effect of determiner, $F_1(1, 31) = 2.14, p > .05$, $F_2(1, 31) = 1.97, p > .05$, and no interaction of sentence structure and determiner, $F_s < 1$. Results indicate that more difficulty was experienced when completing reduced than unreduced sentences, regardless of *only*. However, there was no statistically reliable evidence in favour of a delayed garden path effect for reduced sentences with *only*. Sentence-completion reading times were numerically longer, but did not differ significantly for reduced sentences with and without *only*.

**Comparison of first pass and re-reading times for “short” and “long” relative clause sentences**

We conducted analyses comparing first pass and re-reading times obtained in the present experiment for “long” relative clause sentences with those obtained by Paterson et al. (1999) for “short” relative clause sentences. These enabled us to compare the influence of *only* on parsing of qualitatively different forms of relative clause sentence. An example material is shown in Sentence 11, divided into six regions of analysis used by Paterson et al.

11. The / Only teenagers (who were) | invited a juggler | straightaway.

Region 4 contained the verb *invited* that disambiguates reduced sentences. Mean first pass and re-reading times from the current study are repeated in Table 4 alongside first pass and re-reading times obtained by Paterson et al. (1999) for Region 4 of “short” relative clause sentences.
At Region 4, Paterson et al. (1999) found garden path effects for reduced relative clause sentences regardless of only. However, in the present study there was no main effect of sentence structure in first pass reading times for the critical region of “long” reduced relative clause sentences. In conducting analyses of first pass reading times for “short” and “long” sentences we would expect an interaction of relative clause type and sentence structure if garden path effects occurred for “short” but not for “long” reduced sentences. We would not expect an interaction of sentence structure and determiner as this would indicate garden path effects for “short” and “long” reduced sentences with and without only. Nor would we expect an interaction of relative clause type, sentence structure, and determiner, as this would indicate that garden path effects occurred for “long” reduced sentences either with or without only.

First pass reading times were longer for “long” than for “short” relative clause sentences, $F_1(1, 62) = 19.95, p < .001$, and $F_2(1, 66) = 32.53, p < .001$, and longer for reduced than for unreduced sentence forms, $F_1(1, 62) = 3.89, p < .05$, and $F_2(1, 66) = 4.54, p < .05$. However, there was no reliable effect of determiner, $F_1(1, 62) = 1.33, p > .05$, and $F_2(1, 66) = 5.32, p < .05$. Critically, the interaction of relative clause type and sentence structure was significant by subjects and marginal by items, $F_1(1, 62) = 7.17, p < .01$, and $F_2(1, 66) = 3.41, p < .07$. This indicated garden path effects for “short” but not for “long” reduced sentences. There was no two-way interaction of sentence structure and determiner, or three-way interaction of relative clause type, sentence structure and determiner, $Fs < 1$, and the two-way interaction of relative clause type and determiner was not significant, $F_1(1, 62) = 2.84, p > .05$, and $F_2(1, 66) = 2.61, p > .05$. Results indicated that in first pass reading times there were garden path effects for “short” reduced sentences, but not for “long” reduced sentences.

When Paterson et al. (1999) examined re-reading times, they found longer re-reading times for reduced sentences without only than for unreduced counterparts, but no difference between reduced and unreduced sentences with only. This indicated that only facilitated reanalysis following initial misanalysis of “short” reduced sentences. Similarly, in the present experiment reading times for reduced sentences without only were longer than those for unreduced counterparts, but there were no reliable differences in re-reading times for reduced and unreduced sentences with only.

<table>
<thead>
<tr>
<th>Source</th>
<th>Measure</th>
<th>Measure</th>
<th>The Reduced</th>
<th>The Unreduced</th>
<th>Only Reduced</th>
<th>Only Unreduced</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>$M$</td>
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<td>$SE$</td>
<td>$M$</td>
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</tr>
<tr>
<td>Paterson et al. (1999)</td>
<td>First pass reading time</td>
<td>272</td>
<td>15.7</td>
<td>238</td>
<td>17.6</td>
<td>250</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>First pass reading time</td>
<td>324</td>
<td>17.5</td>
<td>317</td>
<td>12.5</td>
<td>314</td>
</tr>
<tr>
<td>Paterson et al. (1999)</td>
<td>Re-reading time</td>
<td>155</td>
<td>28.9</td>
<td>31</td>
<td>11.6</td>
<td>68</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>Re-reading time</td>
<td>139</td>
<td>25.8</td>
<td>51</td>
<td>11.9</td>
<td>77</td>
</tr>
</tbody>
</table>

In ms.
Further analyses compared re-reading times for “short” and “long” relative clause sentences at Region 4. There was no main effect of relative clause type, $F$s < 1. However, re-reading times were longer for reduced than for unreduced sentences, $F_1(1, 62) = 28.43, p < .001$, and $F_2(1, 66) = 30.86, p < .001$, and shorter for sentences with than without *only*, $F_1(1, 62) = 8.03, p < .01$, and $F_1(1, 66) = 9.33, p < .01$. Importantly, there was a significant two-way interaction of sentence structure and determiner, $F_1(1, 2) = 13.73, p < .001$, and $F_2(1, 66) = 22.79, p < .01$, but no two-way interaction of relative clause type and determiner, and no three-way interaction of relative clause type, determiner, and sentence structure, all $F$s < 1. The pattern of re-reading times was equivalent for “short” and “long” sentences.

Discussion

Before considering theoretical ramifications of our findings, we compare the results from the present eye tracking study to the Paterson et al. (1999) results. In contrast to Paterson et al. we found no evidence of disruption in first pass reading times for the critical region. However, we obtained a reliable first pass regression effect at the disambiguating verb, showing that subjects experienced disruption when reading reduced sentences without *only*. No such effect occurred for unreduced sentences or reduced sentences with *only*, and a similar pattern was obtained for re-reading times. The absence of first pass reading time effects for “long” as compared to “short” relative clause sentences may reflect differences in eye movement behaviour as a result of different levels of disruption to processing (Frazier & Rayner, 1982; Liversedge, Paterson et al., 1998). It appears that when recovery from a misanalysis was easy in “long” reduced sentences subjects immediately re-read text, but when recovery was more difficult in “short” reduced sentences subjects maintained fixation on the critical word before re-reading text. The statistically reliable results from the present study indicate that readers were garden pathed by “long” reduced sentences without *only* but not by reduced sentences with *only*. However, non-reliable re-reading and sentence completion time differences, along with the reliable total time differences, may be taken to indicate that readers were garden pathed by both forms of “long” reduced sentences, but that effects were delayed in the case of sentences with *only*.

There is no a priori reason why garden path effects should be delayed for reduced sentences with *only*. None of the theoretical positions outlined in the Introduction advocates delayed garden path effects. As the sentence is syntactically disambiguated at Region 4 garden path effects should be localized here or perhaps spill over into the next region. However, we found no statistically reliable results to support a spillover effect. Furthermore, sentence-completion reading times provided no statistically reliable evidence of a delayed garden path. To summarize, the data from the current study can be taken to support two alternative conclusions. Either readers were garden pathed by reduced sentences regardless of *only*, in which case non-significant differences indicate delayed disruption for sentences with *only*. Alternatively, *only* guided parsing of “long” reduced relative clause sentences. We favour the latter of these two possibilities.

Let us now consider the theoretical implications of our findings. Restricted accounts of parsing such as the garden path theory (Frazier, 1979) cannot explain how *only* would prevent or delay a garden path effect for “long” reduced relative clause sentences. According to the garden path theory, ambiguous relative clause sentences are initially processed in line with
minimal attachment, and focus operators should not affect initial parsing decisions. This was not the case in the present experiment. Data from the current experiment and those of Paterson et al. (1999) are also problematic for referential theory. Following the principle of parsimony, only should cause readers to instantiate a discourse model containing focus and contrast sets and to anticipate further modifying information that specifies the nature of the contrast between them. Consequently, readers should avoid being garden pathed. Importantly, this should apply to processing of all types of reduced relative clause sentences. However, Paterson et al. showed that only did not influence initial processing of “short” reduced sentences, whereas in the current study we found that only prevented or delayed garden path effects for “long” reduced sentences. Referential theory cannot account for both sets of results.

Any account of the influence of only on parsing must be sufficiently flexible to explain why only affects initial parsing decisions for certain sentences but not others. Constraint–based approaches to parsing provide this flexibility. At least two constraints affect initial parsing of “short” reduced relative clause sentences. There is a strong constraint favouring a direct object analysis (SVO preference, Bever, 1970; frequency effects or thematic biases, MacDonald, 1994), and a relatively weak constraint from the focus operator favouring a relative clause analysis. However, for “long” reduced sentences the prepositional phrase rules out a direct object analysis, and the parser selects between simple active or reduced relative clause analyses. In this situation, only exerts more of an influence over parsing decisions. Following this account, focus operators, along with many other factors, influence the parsing process. Furthermore, differences in the relative strength of constraints explain why only does not influence initial parsing decisions for “short” reduced relatives, but does for “long” counterparts. This account is consistent with findings from Paterson et al. (1999) and the current study.

Constraint–based accounts also can explain why we obtained longer sentence-completion times and longer total reading times (in Regions 2 and 3) for reduced than for unreduced “long” relative clause sentences. A competition process determines which syntactic analysis is the favoured analysis at any point in the sentence: The more competition between alternatives, the longer it takes to read a sentence. When unreduced sentences are processed, reading times are short as the processing system rapidly settles on the single available syntactic analysis. However, reduced sentences will take longer to process because they are ambiguous, and there is competition between alternative syntactic analyses.

It appears then that constraint–based theories can explain the current findings and those of Paterson et al. (1999). However, constraint–based theorists have argued that off–line completion data provide an independent measure of the strength of constraints at each point in the sentence (e.g., Spivey–Knowlton & Sedivy, 1994). Data from our completion experiments, along with reading time data from this study and from that of Paterson et al. do not support this claim. Our sentence completion experiment showed that only caused subjects to produce more relative clause completions for “short” than for “long” sentence fragments. As Paterson et al. obtained reliable garden path effects for “short” relative clause sentences with and without only, we would have expected similar effects for “long” sentences. However, first pass reading times did not show garden path effects. Thus, our data show a mismatch between results obtained in completion studies and the pattern that we would expect to obtain in a reading experiment. Other studies have also found that the sentence completions need not match reading time measures as predicted by constraint–based theory (e.g., Clifton, Kennison, & Albrecht, 1997; Liversedge, Pickering, Branigan, & Van Gompel, 1998; Murray &
Liversedge, 1994; Pickering, Traxler, & Crocker, 2000; see also Van Gompel, Pickering, & Traxler, 2000). Therefore, we question whether sentence completion measures do provide an independent measure of constraint strength during on-line sentence processing. Also, if constraints are not based on completion likelihoods, then what are they based on?

Our results are consistent with Paterson et al.’s (1999) account of the influence of only on parsing. They argued that only would not influence parsing of “short” reduced relative clause sentences as there is a strong preference to adopt a direct object analysis (Bever, 1970). However, as the prepositional phrase in “long” reduced relatives rules out a direct object analysis, the referential properties of only may have more of an influence over the analysis that is initially assigned to the sentence.

To summarize, results from the present study and that conducted by Paterson et al. (1999) provide a detailed picture of the influence of only on parsing of reduced relative clause sentences. For “short” sentences, only does not modulate the strong preference to initially assign a direct object analysis. However, for “long” relative clause sentences containing a prepositional phrase that rules out a direct object analysis, the focus operator does influence initial syntactic processing. Readers experienced disruption at the disambiguating verb when the sentence began with the, but not when it began with only.

REFERENCES


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Reduced relative clause sentences used in Experiment. Sentences were disambiguated as unreduced relative clause sentences by the inclusion of a relative pronoun and auxiliary verb (i.e., who were).

Only / The soldiers (who were) fought in the tropical jungle suffered psychological problems in later years.

Only / The toddlers (who were) washed in the playroom sulked for the rest of the day.

Only / The Cub Scouts (who were) saluted in the parade blushed with pride and embarrassment.

Only / The motorists (who were) stopped in the car park received a warning about their outdated permits.

Only / The visitors (who were) sketched in the historic city congratulated the artist immediately.

Only / The paratroopers (who were) attacked in the late afternoon received a medal later that year.

Only / The defenders (who were) fouled in the last five minutes complained to the referee immediately.

Only / The heavyweights (who were) punched in the early rounds failed to win the championship.

Only / The teenagers (who were) pushed in the hectic crowd regretted going to the concert.

Only / The drama students (who were) filmed in the local park became famous after completing the degree.

Only / The spies (who were) filmed in the seedy motel threatened to leave the country immediately.

Only / The politicians (who were) cheered in the Houses of Parliament celebrated quietly when they got back home.

Only / The musicians (who were) tutored in the recording booth impressed the manager and obtained a contract.

Only / The teachers (who were) interviewed in the school common room worried for the rest of the day.

Only / The women (who were) painted in the basement studio purchased a portrait at the end of the month.

Only / The teachers (who were) assisted in the school fete congratulated the helpers on a job well done.

Only / The medical trainees (who were) studied in the laboratory relaxed in the afternoon with a glass of wine.

Only / The students (who were) served in the expensive wine bar became drunk on the house red later that evening.

Only / The postgraduates (who were) instructed in the technical college continued their duties for a further six months.

Only / The famous players (who were) coached in the rugby ground triumphed in a game the following week.

Only / The dancers (who were) directed in the gymnasium improved the impressive routine within a month.

Only / The pensioners (who were) helped in the charity shop thanked the manager later that evening.

Only / The postgraduates (who were) taught in the summer school succeeded in the end-of-term exams.

Only / The workers (who were) trained in the machine room became fully qualified engineers the following year.

Only / The visitors (who were) entertained in the lounge bar complimented the host before leaving.

Only / The mountaineers (who were) trained in the Lake District succeeded in the awkward climb later that month.

Only / The ladies (who were) taught in the new classroom enjoyed the lessons at the local college.

Only / The gangsters (who were) shot in the dark alleyway submitted to the rival gang straightaway.

Only / The mercenaries (who were) hunted in the bleak mountains concealed themselves during the day.

Only / The managers (who were) telephoned in the early evening expected a wage rise the next day.

Only / The youths (who were) bullied in the school playground visited a psychiatrist in subsequent years.

Only / The fighter pilots (who were) attacked in the morning parachuted into enemy territory and were captured.