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## Pushed aside: parentheticals, memory and processing

Brian Dillon<sup>a\*</sup>, Charles Clifton<sup>b</sup>, Jr. and Lyn Frazier<sup>a</sup>

<sup>a</sup>Department of Linguistics, University of Massachusetts, Amherst, MA 01003, USA; <sup>b</sup>Department of Psychology, University of Massachusetts, Amherst, MA 01003, USA

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In the current work, we test the hypothesis that ‘at-issue’ and ‘not-at-issue’ contents are processed semi-independently. In a written rating study comparing restrictive relative clauses and parentheticals in interrogatives and declaratives, we observe a significantly larger length penalty for restrictive relative clauses than for parentheticals. This difference cannot be attributed to differences in how listeners allocate attention across a sentence; a second study confirms that readers are equally sensitive to agreement violations in at-issue and not-at-issue contents. A third rating experiment shows that the results do not depend on the restrictive relative clause intervening on the subject-verb dependency. A final experiment shows that the observed effects obtain with definite determiners and demonstratives alike. Taken jointly, the results suggest that the parenthetical structures are processed independently of their embedding utterance, which in turn suggests that syntactic memory may be more differentiated than is typically assumed.

**Keywords:** parentheticals; relative clauses; syntactic complexity; working memory

One might caricature the last 50 years of grammatically oriented sentence processing research in terms of successive roughly decade-long periods. The first focused on the existence or ‘psychological reality’ of syntactic structure (Fodor, Bever, & Garrett, 1974). The second investigated ambiguity resolution and principles characterising preferences in how syntactic structures are computed, from a range of theoretical viewpoints (Bates & MacWhinney, 1989; Frazier, 1987; MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Kello, 1993; *a.o.*). This was followed by a concern with explicit complexity metrics that capture difficulty in unambiguous and ambiguous structures alike. This line of research focused in part on the processing demands associated with syntactic and referential complexity between the terms in a costly dependency such as a subject-verb or filler-gap (Gibson, 1998, 2000; Hale, 2001; Levy, 2008; Warren & Gibson, 2002). This concern with costly syntactic dependencies has in recent years highlighted the need for explicit theories of the memory architecture used to resolve these dependencies. Much current research on the working memory mechanisms that support sentence comprehension emphasises the importance of cue-based retrieval mechanisms for syntactic processing, whose existence is supported by results concerning the speed of memory access (Foraker & McElree, 2007; Martin & McElree, 2008; McElree, 2000; McElree, Foraker, & Dyer, 2003) and similarity-based interference effects in online processing (Gordon, Hendrick, & Johnson, 2001; Lewis & Vasishth, 2005; Van Dyke & McElree, 2006).

The interest in syntactic complexity and memory retrieval mechanisms has focused attention on the processing of a small number of expensive dependencies: subject-verb integration and a number of related filler-gap dependencies such as clefting, relative clauses and *wh*-movement (see Bartek, Lewis, Vasishth, & Smith, 2011). Although the intense focus on a small number of dependencies has led to great insight on the cognitive operations necessary to compute them, this focus has to some extent side-lined the exploration of other structures. In the present paper, we focus on structures whose processing, we argue, does not follow the developing consensus about syntactic complexity effects, be they due to memory retrieval or syntactic integration effects. In particular, we examine structures that introduce ‘not-at-issue’ content as opposed to ‘at-issue’ content, as illustrated in (1). We take appositive structures and parentheticals, as in (1a), to be prototypical instances of the former, contrasting with, for example, restrictive relative clauses, as illustrated in (1b). Note that we refer to structures in (1a) as parentheticals, although they might also be characterised as nominal appositives which contain relative clauses:

- (1) a. That man, the one who was on the cruise, tried to throw a waitress overboard.
- b. That man who was on the cruise tried to throw a waitress overboard.

We base our analysis on Potts (2005), who explored a broad range of conventional implicatures, including the

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\*Corresponding author. E-mail: [brian@linguist.umass.edu](mailto:brian@linguist.umass.edu)

content expressed by parentheticals, appositives and expressives, analysing them as *not-at-issue* content. Roughly speaking, he drew a distinction between the asserted proposition conveyed in an utterance (the *at-issue* content), and a range of other entailments and presuppositions that served to guide the listener in integrating and interpreting the asserted proposition (the *not-at-issue* content). The fact that utterances may be characterised as containing a single, primary assertion and a host of secondary entailments is well established in the semantics and pragmatics literatures, and dates back to Stalnaker (1978). The primary assertion, or the *at-issue* content, is typically taken to be a comment on a *question under discussion* (Roberts, 2012; Tonhauser, 2011).

Potts provided a uniform treatment of the distinction between *at-issue* and *not-at-issue* contents by representing each as a separate dimension of meaning. His core observation was that the semantic contribution of *not-at-issue* content has only limited interaction with *at-issue* content. For instance, *not-at-issue* content typically reflects the speaker's perspective even within the scope of a propositional attitude verb, whereas *at-issue* content need not, and *not-at-issue* content is not part of the truth conditional meaning of the sentence. The limited interaction led Potts to propose a 'multidimensional' semantics, such that *not-at-issue* content's semantic contribution was evaluated independently of the *at-issue* content. Subsequent work has weakened this claim substantially. In particular, it has been noted that *at-issue* and *not-at-issue* contents may in fact interact. The so-called 'crossing' phenomena such as anaphoric reference freely cross the *at-issue* / *not-at-issue* boundary, suggesting that a complete independence of the two sorts of meaning is not desirable (see, e.g. AnderBois, Brasoveanu, & Henderson, 2011). There remain many open issues in the theoretical treatment of these phenomena. For example, in later work Potts (Harris & Potts, 2009) suggests a pragmatic rather than semantic account of *not-at-issue* meaning, while others propose a semantic account with a unidimensional semantics (see Schlenker, 2010, in particular).

For present purposes, it suffices to assume that *not-at-issue* content is not integrated into a sentence in a fully determinate manner on a par with *at-issue* content. Given an assumption of limited interactivity, an interesting question arises as to whether different types of linguistic material create comparable processing costs. In the present paper, we ask whether syntactic complexity in parenthetical asides contributes to perceived syntactic complexity in a way that mirrors *at-issue* content.

One way to think about parentheticals is to consider them to be functionally separate speech acts from their embedding clause. It is intuitive to think of appositives and parentheticals as asides in this way. For instance, imagine a speaker uttering a sentence that consists of a

very high pitch range, followed by a portion in a low pitch, and then returning to a high pitch, as in (2).

(2) \_\_\_\_\_

If one were asked to judge the average pitch of such an utterance, it seems plausible that the low portion of the utterance should exert some effect, lowering the overall perceived pitch of the utterance. Our intuition is that, if the low segment is a parenthetical addressed to a different individual, then the pitch of the low, parenthetical segment might not influence the judged pitch of the overall utterance. If true, this would presumably reflect the perceiver treating the parenthetical almost as if it were a separate utterance. This is the intuition behind the hypothesis pursued here: we expect that appositives and parentheticals will be treated as asides, crucial to the overall discourse but quasi-independent of their embedding utterance. If parentheticals are parsed as functionally separate speech acts in this way, then we predict that the properties of parenthetical asides will have a limited impact on the perceived properties of their embedding clause.

It has been widely noted that increasing the amount of material inside a dependency such as a subject-verb or a filler-gap dependency increases processing difficulty (Bartek et al., 2011; Gibson, 1998; Grodner & Gibson, 2005; Hale, 2001; Levy, 2008; Lewis & Vasishth, 2005; McElree et al., 2003; Van Dyke & Lewis, 2003; Warren & Gibson, 2002). For example, one long-distance dependency that has been well studied is the filler-gap relation in relative clause structures in English (3):

- (3) a. The man that chased the cat ran away.  
 b. The man that chased the cat Bill set free ran away.

There is a clear contrast in the difficulty between (3a) and (3b), with the additional embedded object relative in (3b) leading to a perception of difficulty. The mechanism by which the extra material leads to this perception varies from theory to theory. For example, Warren and Gibson (2002) argue that the appropriate metric is the number of new discourse entities that are introduced between two elements in a syntactic dependency (see also Gibson, 1998). Another account of syntactic complexity invokes similarity-based interference (Lewis & Vasishth, 2005). On this account, the addition of an extra noun phrase (NP) constituent encoding in (3b) leads to difficulty when the parser needs to retrieve the representation of the subject headed by *the man* upon reaching the verb *ran*. Surprisal-based accounts of syntactic comprehension (Hale, 2001; Levy, 2008) attribute the difficulty in (3b) to the surprise the parser encounters when reaching the relatively low-probability embedded object relative structure in (3b). As a relatively unlikely continuation of the sentence, this

structure engenders a costly re-ranking of possible parses of the input, leading to a perception of syntactic complexity.

We report several experiments designed to test whether lengthening a parenthetical (one containing a relative clause) introduces processing complexity in the same way as lengthening a restrictive relative clause does. Consider (4):

- (4) a. That man who chased the cat Bill set free ran away.
- b. That man, the one who chased the cat Bill set free, ran away.

In (4b), the object relative clause is contained in a parenthetical, and thus is not-at-issue. As mentioned earlier, it is intuitive to think of parentheticals as asides that are treated almost as if they were separate speech acts from the main utterance. If this is true, one might hypothesise that the parsing operations that construct the parenthetical proceed independently of those that construct the at-issue main clause. One way in which processing might be said to proceed independently for not-at-issue content is if there are separate memory stores for parenthetical and main clause syntactic content. Alternatively, one might think of at-issue and parenthetical contents drawing on separate pools of computational resources during comprehension. If the parenthetical is processed independently of the at-issue content in this way, then on a number of theories about the source of syntactic complexity effects, one predicts less of a cost for the additional object relative in (4b) relative to (4a). For instance, if the metric of complexity is the introduction of new discourse referents while integrating long-distance syntactic dependencies, as in Warren and Gibson (2002), then one might suppose that introducing discourse referents in not-at-issue content would not burden at-issue syntactic dependencies. Alternatively, if the difficulty in (4a) is due to retrieval interference caused by the extra subject encoding *Bill* at the matrix verb *ran* (as in Van Dyke & Lewis, 2003), then one might argue that the parser distinguishes at-issue and not-at-issue contents at retrieval, and so might show less interference from not-at-issue content. These are very different accounts of the syntactic complexity effects, but in the present case they capture the same core intuition about the distinction between at-issue and not-at-issue contents. Independent processing of at-issue and not-at-issue contents should lead to a diminished impact of not-at-issue syntactic complexity on perceived difficulty.

The first experiment to be reported here introduces a relative clause between the terms of a subject-verb dependency. Given a model in which both at-issue and not-at-issue contents are represented in the same memory store, or use the same parsing resources, one would expect

comparable costs of lengthening the intervening material for the two structures. However, if parentheticals are processed as quasi-distinct speech acts, then one might well expect a smaller effect of lengthening a parenthetical than a restrictive relative clause.

## Experiment 1

In Experiment 1, we aimed to determine how the status of a structure – parenthetical or restrictive relative – interacts with the perceived complexity of a sentence. We assume that processing difficulty is reflected in acceptability judgements (following much previous work; Frazier & Clifton, 1989; Sprouse, Fukuda, Ono, & Kluender, 2011; Warren & Gibson, 2002; *a.o.*). We investigated this in two ways. First, we asked whether lengthening a relative clause that modifies a subject would show comparable effects for parentheticals and restrictive relative clauses. We manipulated the length of the relative clause by adding an additional object relative clause to introduce syntactic complexity. Second, we asked whether a *wh*-dependency that spanned the relative clause would be as difficult for parentheticals as it was for restrictive relative clauses. These two (potentially independent) sources of syntactic complexity – *wh*-movement and length – provide two ways of testing the hypothesis that parentheticals and restrictive relative clauses are processed independently. If parentheticals are truly processed independently from at-issue content, then we expect the penalty for both syntactic complexity and *wh*-movement to be lessened for parentheticals compared to restrictive relative clauses.

To evaluate the perceived difficulty of the structures in question, we measured naturalness judgements on a 7-point Likert scale. Participants were asked to judge how ‘natural’ a sentence was, with judgements ranging between 1 (‘very unnatural’) and 7 (‘very natural’). Examples of the critical experimental sentences appear in Table 1.

## Methods

### Subjects

Forty-eight speakers of English were recruited using Amazon’s Mechanical Turk (<https://www.mturk.com>). Completion of the survey took approximately 20 minutes. Participation was restricted to workers with IP addresses in the USA, and all 48 participants self-reported as native speakers of English in a demographic survey. Of the 48 participants, only eight reported more than basic knowledge of another language. Participants gave informed consent, and were paid US\$5 for their participation in the experiment.

### Materials

We used 24 experimental item sets comprising the eight conditions shown in Table 1. We employed a fully crossed

Table 1. Illustration of material in Experiment 1.

| Length | Structure | Syntax  |   |
|--------|-----------|---------|---|
| Short  | Parenth   | Decl    | That butcher, the one in the busy shop, bought his meat from local farmers.                             |
| Long   | Parenth   | Decl    | That butcher, the one in the busy shop Amy visited on Third Avenue, bought his meat from local farmers. |
| Short  | Restr     | Decl    | That butcher who was in the busy shop bought his meat from local farmers.                               |
| Long   | Restr     | Decl    | That butcher who was in the busy shop Amy visited on Third Avenue bought his meat from local farmers.   |
| Short  | Parenth   | Wh-ques | Who did that butcher, the one in the busy shop, buy his meat from?                                      |
| Long   | Parenth   | Wh-ques | Who did that butcher, the one in the busy shop Amy visited on Third Avenue, buy his meat from?          |
| Short  | Restr     | Wh-ques | Who did that butcher who was in the busy shop buy his meat from?  |
| Long   | Restr     | Wh-ques | Who did that butcher who was in the busy shop Amy visited on Third Avenue buy his meat from?            |

2 × 2 × 2 design, with the factors syntax (*wh-question* or *declarative*), sentence length (*long* or *short*) and structure (*parenthetical* versus *restrictive*). *Wh*-questions versions were derived from declarative sentences by questioning either a direct object or an indirect object. Every condition contained a modifier on the matrix subject: a restrictive relative clause or a parenthetical containing a relative clause (*the one who...*). This relative clause interrupted the subject-verb dependency in all conditions, and intervened between the elements of an additional filler-gap dependency in the *wh*-question conditions. Parenthetical structures were always offset by commas and contained a relative clause headed by *the one*, providing a combination of implicit prosodic and explicit syntactic cues that unambiguously signal a parenthetical structure. In contrast, the restrictive structures were always introduced by *who was*, and were not set off with any punctuation. In the short conditions, the content of the modifier clause was either a prepositional phrase (such as the locative *in the busy shop*) or a verb phrase in the passive voice (*caught in the scandal*). Long conditions additionally had an object relative clause modifying the final noun phrase in the relative clause (*in the busy shop Amy visited on Third Avenue*). The subject of the embedded object relative was always a proper name, and there was a variable amount of material that intervened between the gap site inside the object relative and the right edge of the entire

parenthetical or restrictive clause. The full set of experimental items used may be found in [Appendix 1](#).

### Procedure

The critical sentences were distributed into eight Latin Square lists, and six participants were assigned to each list. For each participant, the order of presentation was randomised subject to the constraint that no two critical experimental items appeared adjacent to each other. The 24 critical experimental items were combined with 72 filler sentences. Fillers contained items from unrelated experiments, and comprised a range of acceptable and unacceptable structures of comparable complexity. Unacceptable items included unlicensed negative polarity item dependencies, ungrammatical reflexive dependencies and ungrammatical agreement morphology.

The questionnaire was administered over the Internet using the IbexFarm experimental software (<http://spellout.net/ibexfarm>). Participants were instructed to rate sentences on a 1–7 Likert scale according to what sounded like natural English, and were given four examples to introduce them to the task. Each trial consisted of a single sentence presented on the screen, and the seven response options were listed below the sentence. Participants responded by choosing their desired rating using either the mouse or the number keys on the keyboard. To remind participants of the interpretation of the Likert scale, the left end of the scale was labelled ‘very unnatural’, and the right end of the scale was labelled ‘very natural’. Participants were allowed to take as long as they liked to judge the sentences.

### Results

The average rating for each critical condition is presented in [Table 2](#), along with by-participant standard errors corrected for between-participant variance following the suggestion of Bakeman and McArthur (1996). The rating scores were analysed using separate by-participants ( $F_1$ ) and by-items ( $F_2$ ) repeated measures analysis of variances (ANOVAs). This analysis revealed a significant main effects of sentence length [ $F_1(1,47) = 36.8, p < 0.0001, F_2(1,23) = 41.6, p < 0.0001$ ], sentence syntax [ $F_1(1,47) =$

Table 2. Means of ratings, Experiment 1. Parentheses represent standard error corrected for between-participant variance, following Bakeman and McArthur (1996).

| Length | Restrictive  |               | Parenthetical |               |
|--------|--------------|---------------|---------------|---------------|
|        | Declarative  | Interrogative | Declarative   | Interrogative |
| Short  | 6.1 (± 0.10) | 5.2 (± 0.14)  | 6.1 (± 0.09)  | 5.9 (± 0.10)  |
| Long   | 5.1 (± 0.10) | 4.3 (± 0.13)  | 5.9 (± 0.07)  | 5.6 (± 0.10)  |

20.0,  $p < 0.0001$ ,  $F_2(1,23) = 6.8$ ,  $p < 0.05$ ] and modifier structure [ $F_1(1,47) = 56.0$ ,  $p < 0.0001$ ,  $F_2(1,23) = 47.7$ ,  $p < 0.0001$ ]. In addition, the ANOVA revealed a significant interaction of length and modifier structure [ $F_1(1,47) = 25.7$ ,  $p < 0.0001$ ,  $F_2(1,23) = 13.3$ ,  $p < 0.01$ ], as well as a significant interaction of modifier structure and syntax [ $F_1(1,47) = 12.8$ ,  $p < 0.001$ ,  $F_2(1,23) = 8.0$ ,  $p < 0.01$ ]. No other interactions reached significance (all  $F$ 's  $< 1.5$ ).

### Discussion

The results of Experiment 1 revealed main effects of each experimental factor, confirming that additional sentential complexity negatively impacted acceptability ratings in our task. Specifically, it was observed that longer sentences were judged as less acceptable than shorter and less complex sentences, and that *wh*-questions were less acceptable than their corresponding declarative sentences. In addition, sentences with parenthetical structures received higher overall ratings than did sentences with restrictive relative structures.

Interestingly, the results show that lengthening the restrictive relative decreased the acceptability of the utterance more than it did the parenthetical, for both declarative and interrogative sentences alike. In addition, it was seen that *wh*-movement only contributed to perceived complexity for restrictive relatives; there was no apparent penalty for *wh*-movement when it spanned parenthetical structures. The interaction of sentence type with relative clause type, and the interaction of relative clause type with length both suggest that the perceived acceptability of parenthetical structures is not substantially impacted by the presence of *wh*-movement or increased structural complexity.

Our results suggest that there is no difference in the short restrictive and short parenthetical conditions. One might have thought that parentheticals would be processed more easily than restrictives if the parenthetical is effectively invisible to the task of retrieving the matrix subject given the matrix verb. However, the lack of a difference here is likely to be controlled by other factors that modulate acceptability of the two structures in question, such as felicity of the two structures in out-of-the-blue contexts, appropriateness for the perceived register of the experiment, frequency of use, etc. For this reason, we do not believe this lack of an effect constitutes counterevidence to our hypothesis. The relevant evidence is the fact that adding length to the relative clause intervening between matrix subject and verb disproportionately depressed acceptability of restrictives compared to parentheticals.

By hypothesis, the drop in acceptability observed for additional complexity in the restrictive relative clause structures reflects mutual interference between the

restrictive relative clause and the main clause, due to overlap in the processing resources that they recruit. The finding that these penalties are significantly smaller for parentheticals is consistent with the hypothesis that the parenthetical and the main utterances are processed independently. This conclusion is compatible with a range of assumptions about the mechanisms that contribute to the decreased acceptability effects in the restrictive relative structures. For instance, if one assumes that the process of creating a subject-verb dependency requires an interference-prone memory retrieval process (Bartek et al., 2011; Van Dyke & Lewis, 2003), then the length penalty for restrictive relative clauses might reflect an interference effect from the additional subject encoding present in the long condition (Van Dyke, 2007; Van Dyke & Lewis, 2003). On this model of the length effect, then the present results suggest that the content of the parenthetical clause does not interfere with the core memory retrieval processes that construct the subject-verb dependency. This would suggest that the parser maintains a distinction between parenthetical and restrictive content in short-term memory, and that these two forms of content are processed independently by using at-issue / not-at-issue as retrieval cues to distinguish the two types of representation at retrieval. Alternatively, it may be the case that parenthetical content and at-issue content are represented in distinct memory stores, which would a priori limit the degree to which the two structures might interfere in short-term memory.

However, there is another possible explanation for the interaction between relative clause type and length. Namely, it is possible that perceivers simply do not allocate much attention to parenthetical content, and so it does not appear to interact with at-issue content simply because it draws fewer processing resources than at-issue restrictive relative clauses. It has been widely observed that listeners and readers do not allocate their attention evenly throughout a sentence. In listening, for example, Cutler (1976) and Cutler and Fodor (1979) show that prosodically or semantically focusing a phrase leads to faster phoneme-monitoring times for words in the phrase. Similarly, in reading, focused material is apparently processed more deeply than unfocused material in that small semantic changes are more reliably detected in focused material (Sturt, Sanford, Stewart, & Dawydiak, 2004).

This raises the possibility that the results of Experiment 1 should not be attributed to parentheticals being processed independently, but rather to the possibility that listeners and readers allocate more attention to at-issue content, and less to not-at-issue content. We address this possibility in Experiment 2.

## Experiment 2

The second experiment used an ungrammaticality detection paradigm to assess differences in attention paid to restrictive and parentheticals. Readers were presented with a series of sentences that were grammatical and acceptable, or ungrammatical or unacceptable in various ways. In the critical conditions, a subject-verb agreement violation (or a non-violating instance of agreement) was contained within a restrictive relative clause or a parenthetical. If readers direct less attention to parenthetical, not-at-issue content than to restrictive relative clauses, then they should fail to detect ungrammaticality at higher rates in not-at-issue content than in at-issue content.

### Method

#### Subjects

Forty-eight subjects were recruited using Mechanical Turk, subject to the same constraints as in Experiment 1. They gave informed consent and were paid \$5 for their participation. The experiment took on average 20 minutes.

#### Materials

We modified the 24 declarative sentences from Experiment 1 for Experiment 2. We employed a  $2 \times 2$  design, crossing grammaticality and modifier structure. All conditions were presented in their 'long' versions from Experiment 1. The tense on the embedded object relative clause was changed to present tense so that there was overt agreement present in every example. One substantial change was made to the items from Experiment 1: rather than having a singular proper name as the subject of the additional relative clause that served to make the restrictive relative clause or parenthetical long, in Experiment 2 half of the items had a plural or conjoined subject in this position. Grammaticality was determined by whether the verb in the additional relative clause agreed in number with its subject. Table 3 presents examples of all of the four resulting conditions.

Table 3. Illustration of material in Experiment 2.

| Gram   | Structure |  |
|--------|-----------|--|
| Gram   | Parenth   | That economist, the one who was at the conference Paul attends every year in Rome, made fun of the banker. |
| Ungram | Parenth   | *That economist, the one who was at the conference Paul attend every year in Rome, made fun of the banker. |
| Gram   | Restr     | That economist who was at the conference Paul attends every year in Rome made fun of the banker.           |
| Ungram | Restr     | *That economist who was at the conference Paul attend every year in Rome made fun of the banker.           |

These items were divided in a Latin Square fashion into four counterbalanced lists, each of which contained six experimental sentences in each of the conditions. The resulting 24 sentences were combined with 72 filler sentences, including grammatical and acceptable sentences with negative polarity items or with verbal complements vs. adjuncts, and sentences with either acceptable or unacceptable antecedent-anaphor relations. The items were blocked such that half of the sentences had singular subjects in the additional relative clause, and half had plural subjects.

### Procedure

The experimental procedure was identical to Experiment 1.

### Results

The mean ratings (and their corrected standard errors) appear in Table 4. Sentences with grammatical agreement were rated higher than those with agreement violation [ $F_1(1,47) = 31.9, p < 0.001$ ;  $F_2(1,23) = 58.6$ ]. Similarly, sentences with parentheticals were rated higher than sentences with restrictive relative clauses [ $F_1(1,47) = 51.8, p < 0.001$ ;  $F_2(1,23) = 67.2, p < 0.001$ ]. However, the interaction was not significant ( $F$ 's  $< 0.10$ ).

The main finding in Experiment 2 is that the perception of the agreement violation was identical in parentheticals and restrictive relative clauses. Experiment 2 thus provided no evidence that attention differed between restrictive relative clauses and parentheticals, as grammatical errors were detected just as readily in the latter as in the former. To be sure, this does not conclusively prove that there were no differences in attention in the naturalness ratings of Experiment 1. After exposure to some sentences, some of which were complex but grammatical in Experiment 1 and ungrammatical in Experiment 2, subjects could in principle change their reading strategy. However, we note that long restrictives were rated as less natural than long parentheticals in Experiment 2, replicating a pattern seen in the results of Experiment 1. This convergence suggests that response strategies may not have changed drastically between the two experiments. We conclude that Experiment 2 provides evidence that

Table 4. Means of ratings, Experiment 2. Parentheses represent standard error corrected for between-participant variance, following Bakeman and McArthur (1996).

|               | Restrictive         | Parenthetical       |
|---------------|---------------------|---------------------|
| Grammatical   | 4.77 ( $\pm 0.17$ ) | 5.37 ( $\pm 0.15$ ) |
| Ungrammatical | 3.63 ( $\pm 0.18$ ) | 4.29 ( $\pm 0.17$ ) |

readers attend as much to parentheticals as to restrictive relatives in sentence naturalness judgement tasks.

### Experiment 3

Taken together, Experiments 1 and 2 suggest that parenthetical structures do not contribute to the perception of difficulty as much as restrictive relative clause structures, and that this difference is not due to differences in the attention afforded to each type of structure. In order to understand why parenthetical structures do not contribute to processing difficulty in the same manner as restrictive relatives, it is important to understand the nature of the complexity effects observed in Experiment 1. As discussed above, there are a number of attractive theories of why increasing the amount of linguistic material in a phrase increases processing difficulty. One possibility is that material inside a restrictive relative clause contributes to retrieval interference at the verb, when the subject is retrieved for thematic integration (Bartek et al., 2011; Van Dyke, 2007; Van Dyke & Lewis, 2003; see also Gibson 1998, 2000). With regard to the difficulty observed in the *wh*-question structures, the observed penalty may reflect the need to maintain an unresolved A' dependency in short-term memory (Frazier & Clifton 1989; Gibson 1998; Wanner & Maratsos, 1978; among others). The data from Experiment 1 are generally compatible with these theories, with the stipulation that the length inside a parenthetical does not contribute to retrieval interference, and the difficulty associated with holding an unintegrated filler is minimised when processing parenthetical content.

One important finding in Experiment 1 is that the difficulty associated with the relative clause length and the difficulty associated with *wh*-movement were independent. One might have expected the effect of increasing the length of the restrictive relative clause to be larger when it was additionally spanned by a *wh*-dependency. This was not observed: the penalty due to lengthening the restrictive relative clause was not greater for the interrogatives than for the declaratives.

Experiment 3 was designed to address the source of the length penalty in Experiment 1. As mentioned, one possibility was that the length penalty reflected retrieval interference at the point of processing the matrix verb. On this account, length should only contribute to processing difficulty if it interrupts a long-distance dependency, such as the subject-verb dependency. Accounts such as Gibson (1998, 2000), which attribute some portion of length effects to storage costs, make similar predictions: additional length should only contribute to difficulty when it spans a long-distance syntactic dependency.

However, it is possible that the mutual interference between the restrictive relative clause and the matrix clause is more general than these accounts suggest. For instance, the length effects may simply stem from the need

to maintain multiple similar syntactic encodings in memory at the same time when processing restrictive, at-issue content. Parenthetical structures may alleviate some of this difficulty by functionally creating different memory 'workspaces', limiting the mutual interference engendered by the similar syntactic encodings. On such an account, additional syntactic complexity contributes processing difficulty as a function of its similarity to other encodings in the at-issue content store, regardless of whether that complexity spans a syntactic dependency. Experiment 3 attempts to tease these two possibilities apart by comparing relative clauses that modify subjects with those that modify objects. If the complexity seen in Experiment 1 arises only when the additional length interrupts a syntactic dependency, then no such length effects should be observed for relative clauses that modify objects.

### Method

#### Subjects

Forty-eight volunteers participated in Experiment 3. Participants were recruited from the undergraduate population at the University of Massachusetts, Amherst, and were compensated with course credit for their time. Participants gave informed consent. All participants were native speakers of American English.

#### Materials

We used 24 experimental item sets comprising the eight conditions shown in Table 5. We employed a fully crossed

Table 5. Illustration of material in Experiment 3.

| Length | Structure | Position |  |
|--------|-----------|----------|--|
| Short  | Parenth   | Subject  | That student, the one who was in the art class, met the art critic.                        |
| Long   | Parenth   | Subject  | That student, the one who was in the art class Lucy teaches on Sunday, met the art critic. |
| Short  | Restr     | Subject  | That student who was in the art class met the art critic.                                  |
| Long   | Restr     | Subject  | That student who was in the art class Lucy teaches on Sunday met the art critic.           |
| Short  | Parenth   | Object   | The student met that art critic, the one who was in the art class.                         |
| Long   | Parenth   | Object   | The student met that art critic, the one who was in the art class Lucy teaches on Sunday.  |
| Short  | Restr     | Object   | The student met that art critic who was in the art class.                                  |
| Long   | Restr     | Object   | The student met that art critic who was in the art class Lucy teaches on Sunday.           |

$2 \times 2 \times 2$  design, with the factors modifier position (*subject* or *object*), sentence length (*long* or *short*) and modifier structure (*parenthetical* versus *restrictive*). *Subject* modifier conditions were largely identical to those in Experiment 1. When the original items from Experiment 1 did not have a direct object present in the matrix clause, however, they were changed for Experiment 3 so that they did. *Object* modifier conditions were then derived from the subject modifier sentences by changing the position of the relative clause to modify the object position. The noun that hosted the relative clause was always introduced by the demonstrative *that*, and the other noun was introduced with the definite article *the*. A full list of the experimental items is found in [Appendix 2](#).

### Procedure

Subjects were tested individually in 20-minute sessions. The programme Linger (<http://tedlab.mit.edu/~dr/Linger/>) was used to present the 24 experimental items, combined with 112 filler sentences and sentences from other unrelated experiments, in individually randomised order. Eight counterbalancing forms were used, so that each of the 24 experimental sentences was presented in each experimental condition in one counterbalancing form. A sentence was presented in its entirety on a video monitor, and the subject pressed a key on the computer keyboard after reading it. A 7-point naturalness rating scale then appeared, with '1' labelled as unnatural and '7' as natural, and the subject had pressed the appropriate number key. Responses, reading and decision times were recorded (times are not reported, being uninformative).

### Results

Due to a coding error, the data from one item could not be analysed, and so were excluded from the analysis. The rating scores, which appear in [Table 6](#), were analysed using separate by-participants ( $F_1$ ) and by-items ( $F_2$ ) repeated measures ANOVAs. Crucially, there was a significant interaction of length and modifier structure [ $F_1(1,47) = 10.6, p < 0.01, F_2(1,22) = 10.5, p < 0.01$ ]. Lengthening the relative clause decreased ratings more when the relative clause was restrictive than when it was parenthetical, as observed in Experiment 1. The

interaction between length, modifier structure and modifier position did not approach significance (all  $F$ 's  $< 1$ ). In addition, the analysis revealed significant main effects of sentence length [ $F_1(1,47) = 63.4, p < 0.0001, F_2(1,22) = 22.0, p < 0.001$ ] and modifier structure [ $F_1(1,47) = 9.8, p < 0.01, F_2(1,22) = 15.0, p < 0.001$ ]: long sentences and sentences with restrictive relative clauses were rated as relatively unacceptable, largely reflecting the low ratings for the long restrictive relative clause sentences. There was additionally a main effect of modifier position that was significant by participants [ $F_1(1,47) = 5.9, p < 0.05$ ], but only marginally significant by items [ $F_2(1,22) = 3.2, p < 0.1$ ]. This marginal main effect was qualified by a significant interaction of modifier structure and position [ $F_1(1,47) = 20.7, p < 0.0001, F_2(1,22) = 6.1, p < 0.05$ ]: object modification sentences were rated lower than subject modification sentences only when the modifier was parenthetical.

### Discussion

Experiment 3 revealed two main findings. One, the length effects observed in Experiment 1 are very similar for relative clauses that modify subjects and objects alike. Restrictive relative clauses show sizeable length effects in both positions, and parentheticals show diminished effects in both positions. The second major finding from Experiment 3 is that parentheticals receive higher ratings when they modify subjects compared to objects. Restrictive relative clauses, on the other hand, receive similar ratings in both positions.

The pattern of length effects observed in Experiment 3 rules out accounts of the length effect that attribute the difficulty to additional length interrupting a syntactic dependency. This includes accounts that claim the additional material should cause interference in retrieving the subject at the critical verb (Lewis, Vasishth, & Van Dyke, 2006; Van Dyke, 2007; Van Dyke & Lewis, 2003) and accounts that claim the introduction of an extra discourse entity in the middle of a syntactic dependency will cause difficulty (e.g. Gibson, 1998, 2000). Instead, it appears that the interference between the content of the restrictive relative clause and the matrix clause is more general, and obtains even when the relative clause is in final position. We additionally observed that parentheticals are preferred when they modify subjects, compared to objects, in our experimental materials. If our participants construed the subject position in this experiment as reflecting given information (perhaps according to an implicit given-new contract, Clark & Haviland, 1977), then the preference for this position might reflect a preference for parentheticals to comment on given information. However, this experiment was not designed to test this hypothesis, and so this must remain speculative pending further research.

Table 6. Means of ratings, Experiment 3. Parentheses represent standard error corrected for between-participant variance, following Bakeman and McArthur (1996).

|       | Subject            |                    | Object             |                    |
|-------|--------------------|--------------------|--------------------|--------------------|
|       | Restrictive        | Parenthetical      | Restrictive        | Parenthetical      |
| Short | 5.9 ( $\pm 0.10$ ) | 6.2 ( $\pm 0.08$ ) | 6.0 ( $\pm 0.12$ ) | 5.7 ( $\pm 0.15$ ) |
| Long  | 4.9 ( $\pm 0.15$ ) | 6.0 ( $\pm 0.09$ ) | 5.0 ( $\pm 0.14$ ) | 5.3 ( $\pm 0.11$ ) |

The results of Experiment 3 also rule out an alternative prosodic explanation for the decreased length effect seen for parentheticals in Experiments 1 and 3. It has been argued that punctuation is closely related to the prosodic structure of a sentence (Chafe, 1988; Kerkhofs, Vonk, Schriefers, & Chwilla, 2008; Steinhauer, 2003; Steinhauer & Friederici, 2001). For example, Steinhauer and Friederici (2001) found that German readers' behavioural and neural responses to commas mirror the responses generated by auditory prosodic breaks. The close relationship between prosodic boundaries and punctuation is less clear, however, for the prosodic break that is sometimes inserted between a subject and its verb in English. Although standard English punctuation conventions do not require a comma between a heavy subject and its verb, speakers are likely to insert a prosodic break in this position. This tendency leads many speakers to insert a comma between a heavy subject and the verb (Chafe 1988; Quirk, Greenbaum, Leech, Svartvik, & Crystal, 1985). Although there is considerable variation between individuals in how reliably they mark prosodic pauses with commas (Steinhauer & Friederici, 2001), we cannot rule out the possibility that our subject pool largely consisted of speakers who expect a comma after a heavy subject. If our subjects expected a comma in this position, then we would observe a decrease in naturalness for the long restrictive conditions but not for the parentheticals, which are always marked with a comma. On this view, our observed interaction of length and modifier structure reflects the fact that only the long restrictive condition violates readers' preferred prosody-punctuation mapping.

Although this account is a plausible alternative explanation of the interaction of length and structure observed for subject-modifying structures in Experiments 1 and 3, it does not predict that the effect should occur in the object-modifying conditions in Experiment 3. In our materials, the parenthetical and restrictive structures in object-modifying position were always sentence final. Because both were always followed by a period, the preferred prosody-punctuation mapping was preserved for both parenthetical and restrictive structures. The results of Experiment 3 demonstrate that the interaction of structure and length survives in the object-modifying conditions, ruling out this potential alternative explanation. A further difficulty with an explanation for our results in terms of prosody comes from the interaction of syntax (declarative sentence vs. *wh*-question) and modifier structure in Experiment 1. The fact that the cost of *wh*-movement was limited to the restrictives cannot plausibly be accounted for in terms of prosody. Overall, it seems that only explanation in terms of decreased interference between at-issue and not-at-issue content can account for all of our experimental results.

#### Experiment 4

The results of previous experiments suggest that at-issue and not-at-issue material contributes differently to the perceived naturalness of a sentence. However, one might object that the restrictive relative clauses we have tested are unusual in that the head NP was introduced by a demonstrative *that* (we thank Laura Kertz, Geoff Pullum and Pauline Jacobson for this observation). Perhaps the demonstrative renders the restrictive relative clause otiose, not necessary for purposes of identifying the intended referent of *that* + nominal. This could lead to exaggerated effects of length selectively in the restrictive conditions. To test for this possibility, we ran an experiment using the materials from Experiment 3 by changing *that* to *the*, as illustrated in (4).

#### Method

##### Subjects

Forty-nine speakers of English were recruited using Amazon's Mechanical Turk (<https://www.mturk.com>). Completion of the survey took approximately 20 minutes. Participation was restricted to workers with IP addresses in the USA, and all participants self-reported as native speakers of English in a demographic survey. Participants gave informed consent, and were paid US\$5 for their participation in the experiment.

##### Materials

The materials were identical to those in Experiment 3, with the exception that the determiner of the critical noun modified by a relative clause structure was changed from the demonstrative *that* to the definite article *the*. An example is provided in Table 7.

##### Procedure

The procedure was identical to Experiments 1 and 2.

#### Results

The rating means and standard errors appear in Table 8. Repeated measured ANOVA analysis by-participants and by-items revealed the crucial significant interaction of length and modifier structure [ $F_1(1,48) = 31.7, p < 0.0001, F_2(1,23) = 16.0, p < 0.001$ ]. As observed previously, lengthening the relative clause had a larger effect on restrictives than on parentheticals. In addition, the main effect of length was significant, [ $F_1(1,48) = 67.1, p < 0.0001, F_2(1,23) = 37.2, p < 0.0001$ ], the interaction of modifier structure and modifier position observed in Experiment 3 was found here again [ $F_1(1,48) = 12.4, p < 0.001, F_2(1,22) = 14.8, p < 0.001$ ].

Table 7. Illustration of material in Experiment 4.

| Length | Structure | Position |   |
|--------|-----------|----------|---|
| Short  | Parenth   | Subject  | The student, the one who was in the art class, met the art critic.                        |
| Long   | Parenth   | Subject  | The student, the one who was in the art class Lucy teaches on Sunday, met the art critic. |
| Short  | Restr     | Subject  | The student who was in the art class met the art critic.                                  |
| Long   | Restr     | Subject  | The student who was in the art class Lucy teaches on Sunday met the art critic.           |
| Short  | Parenth   | Object   | The student met the art critic, the one who was in the art class.                         |
| Long   | Parenth   | Object   | The student met the art critic, the one who was in the art class Lucy teaches on Sunday.  |
| Short  | Restr     | Object   | The student met the art critic who was in the art class.                                  |
| Long   | Restr     | Object   | The student met the art critic who was in the art class Lucy teaches on Sunday.           |

### Discussion

The results of Experiment 4 are qualitatively similar to those of the earlier experiments. In particular, we observed the same effect of length, and interaction of length with modifier structure that was observed in Experiment 3. We also observed the same modifier structure by attachment position interaction as in Experiment 3, such that parentheticals are more highly rated when they modify subjects than when they modify objects.

Experiment 4 thus confirms that the pattern observed in Experiments 1 and 3 is not due to an interaction of demonstrative semantics and restrictive modification. Instead, the length effect appears to hold for relative clauses modified by *the* and *that* alike, in object or subject position. Likewise, the diminished length effects observed for parenthetical structures is not due to the interaction of the demonstrative and the not-at-issue content, as parentheticals that modify nouns introduced by *the* are similarly robust to length effects.

Table 8. Means of ratings, Experiment 4. Parentheses represent standard error corrected for between-participant variance, following Bakeman and McArthur (1996).

|       | Subject            |                    | Object             |                    |
|-------|--------------------|--------------------|--------------------|--------------------|
|       | Restrictive        | Parenthetical      | Restrictive        | Parenthetical      |
| Short | 5.9 ( $\pm 0.09$ ) | 5.9 ( $\pm 0.08$ ) | 6.0 ( $\pm 0.10$ ) | 5.4 ( $\pm 0.09$ ) |
| Long  | 5.0 ( $\pm 0.12$ ) | 5.5 ( $\pm 0.10$ ) | 5.0 ( $\pm 0.09$ ) | 5.1 ( $\pm 0.10$ ) |

### General discussion

In the present paper, we presented four offline ratings studies that contrasted the intuitive acceptability of parenthetical versus restrictive relative structures. Several clear empirical generalisations emerged from our results. First, the drop in acceptability associated with additional syntactic complexity is greatly diminished when that complexity is inside a parenthetical structure, when compared to a restrictive structure (Experiments 1, 3 and 4). The difficulty associated with the additional syntactic complexity is similar for restrictives that modify subjects and objects alike (Experiments 3 and 4), and it is not impacted by the choice of the determiner on the host nominal (Experiment 4). Additionally, the drop in acceptability associated with the introduction of a *wh*-dependency is lessened when that dependency spans a parenthetical than when it spans a restrictive relative clause (Experiment 1). Finally, it was observed that the penalty for subject-verb agreement mismatches is identical in parenthetical and restrictive relative clauses alike (Experiment 2).

This pattern of results suggests that parentheticals do not contribute to perceived syntactic complexity of their embedding clause in the same way that restrictive relative clauses do. Importantly, the observed differences between parentheticals and restrictive relative clauses cannot be attributed to diminished attention to not-at-issue content; comprehenders are equally good at detecting ungrammaticalities in at-issue and not-at-issue alike, suggesting they attend equally to both types of linguistic content. We suggested at the outset that the observed pattern of results arises because the parenthetical clause is functionally parsed (or produced) as if it were a separate speech act. Very broadly, this view predicts a limited interaction between not-at-issue parentheticals and at-issue content, and consequently, limited opportunity for mutual interference.

One important finding about the nature of the interference between complex restrictive relative clauses and their embedding clause is that the penalty for additional complexity arises whether the relative clause modifies a subject or an object. This suggests that the source of the complexity cannot be attributed to extra syntactic complexity that interrupts the subject-verb dependency, a finding that has ramifications for current models of processing complexity. For instance, according to the Discourse Locality Theory (DLT; Gibson, 1998, 2000; Warren & Gibson, 2002), long syntactic dependencies are difficult to process as a function of the number of intervening discourse entities. However, this account does not capture the length effects observed for complex relative clauses that modify objects in Experiments 3 and 4, where the additional discourse referent introduced by the additional length does not interrupt any long-distance syntactic dependency. Likewise, accounts of processing difficulty that attribute complexity to retrieval interference

(e.g. Lewis & Vasishth, 2005; Lewis et al., 2006) predict that the additional length contributes to memory interference at points of memory retrieval. When the additional length modifies a subject, then retrieving that subject upon reaching the matrix verb is made more difficult by the intervening material (Van Dyke, 2007; Van Dyke & Lewis, 2003). However, like the DLT, retrieval interference accounts of the complexity effects observed here predict that no such complexity should arise when the relative clause modifies an object.

Another class of theory for the difficulty associated with additional length attributes the difficulty to low probability or surprising syntactic continuations (Hale, 2001; Levy, 2008). Although we do not have reliable corpus data on the likelihood of the additional length in parentheticals versus restrictive relative clauses, we find it unlikely that these accounts will capture the contrast between complexity in parentheticals and restrictives in our data for the following reason. While the complex parenthetical and restrictive structures differed in terms of their syntactic and semantic relation to their embedding clause, their local syntactic structure was identical in both cases: both had a restrictive relative structure that itself contained an object relative. Thus, the amount of surprisal contributed by the embedded object relative in our stimuli should be essentially identical across the parenthetical and restrictive structures. While we cannot rule out such an account, it seems that if the probability of a continuation is in large part determined by the probability in the local syntactic context, then there is no substantial difference in the likelihood of embedding an object relative in a parenthetical or a restrictive relative clause.

The results suggest that the diminished mutual interference between not-at-issue content and at-issue content reflects a more general fact of the comprehension or production system than suggested by current accounts of syntactic complexity. Instead, we suggest that parentheticals are processed independently of the at-issue material, perhaps in a separate memory store, as a result of their status as quasi-independent speech acts. This view contrasts with an often implicit assumption that there is a single, undifferentiated memory store for a syntactic parse. However, there remain open questions about the best way to characterise the different memory stores invoked on this account. One possibility is that the distinction between parentheticals and restrictives reflects differences in the scope of planning in production. If parentheticals are constructed using an entirely different planning space, drawing on a separate pool of processing resources, then this may ease processing at the planning stage.

Another possibility is that the difference between parentheticals and restrictives resides in comprehension, and reflects independent parser memory stores for each type of material. Such independent memory stores for parentheticals and at-issue material could potentially

minimise proactive interference effects that arise at encoding, such as feature-overwriting effects (Nairne, 1990; Oberauer & Kliegl, 2006). A comprehension account of our results is compatible with previous results on discourse comprehension that suggest that discourse segments on the same level are processed in a single memory store, whereas digressions and asides are processed independently (Redeker, 2006). Redeker presents cross-modal priming evidence which suggests that linguistic material in a given level of discourse is suspended when a digression is processed. Her results suggest that in particular that the material prior to the digression is kept active until the processor returns to it. This finding suggests that the parser is able to simultaneously maintain linguistic material at one level of discourse while it processes a digression or an aside, a sort of limited parallelism that is compatible with multiple memory stores for different sorts of linguistic content. Indeed, one may view parenthetical structures as grammaticised instances of the ‘hypotactic’ discourse relations (roughly, asides) discussed by Redeker. In this case, the relationship between her results and ours is rather direct, and raises the possibility for multiple specific memory stores for linguistic material online.

We cannot at present decide between accounts of our results that place the interference observed in complex restrictive relative clauses in production or comprehension difficulty. In either case, however, the results crucially give support to the core intuition discussed in the introduction: not-at-issue parentheticals are treated as if they were effectively a separate speech act, and this separation is reflected in independent processing of the two types of content. The most important insight in the present findings, then, is the implication that not all linguistic material contributes equally to judgements about a sentence. At a minimum, the current results challenge the assumption that there is a single memory store or set of processing resources for purposes of syntactic comprehension. An interesting goal for future research is to determine exactly the class of elements that are stored or processed separately in this way. We have suggested that the relevant difference is the at-issue / not-at-issue distinction proposed by Potts (2005). However, Potts’ distinction comprises a much broader range of structures than the particular parenthetical structures investigated here. In particular, while not-at-issue content may include syntactically and prosodically set off material such as parentheticals and supplemental asides, it may also include more syntactically and prosodically integrated content such as expressive adjectives (*gosh-darned*), anaphoric epithets (*that jerk*) and honorific marking seen in, for example, Korean and Japanese. It may be that this ‘integrated’ not-at-issue material is processed independently of the at-issue content in a way that mirrors the parentheticals investigated here, but it is also possible that

the syntactic and prosodic differences particular to parentheticals are a necessary condition for the processor to treat them as a separate processing domain.

Although many open questions remain about the nature of the results found here, we hope to have established a number of key generalizations. Chief among these is the limited amount of interaction between parentheticals and their embedding clause, despite the fact that parentheticals are syntactically dependent on their matrix clause. We have suggested that this limited interaction reflects the parser's ability to process them semi-independently, as if they were separate speech acts. More generally, the present results provide an interesting extension of previous work on the perception of syntactic complexity. In our results, syntactic complexity effects were observed in a wider range of contexts than expected on most current theories. However, at the same time, the contrast between parentheticals and restrictive relative clauses suggests that these complexity effects are more limited than previously thought.

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## Appendix 1

The experimental stimuli for Experiment 1 are listed below. Interrogative conditions are presented first in their parenthetical and restrictive forms, followed by declarative conditions. The additional length for *long* conditions is presented in parentheses.

- Interrogative, Parenthetical*: Who did that man, the one on the cruise (Mary took to the Pacific Islands), try to throw overboard?  
*Interrogative, Restrictive*: Who did that man who was on the cruise (Mary took to the Pacific Islands) try to throw overboard?  
*Declarative, Parenthetical*: That man, the one on the cruise (Mary took to the Pacific Islands), tried to throw a waitress overboard.  
*Declarative, Restrictive*: That man who was on the cruise (Mary took to the Pacific Islands) tried to throw a waitress overboard.
- Who did that girl, the one at the big party (John attended at the Fine Arts Center), end up dating?  
Who did that girl who was at the big party (John attended at the Fine Arts Center) end up dating?  
That girl, the one at the big party (John attended at the Fine Arts Center), ended up dating Phil's brother.  
That girl who was at the big party (John attended at the Fine Arts Center) ended up dating Phil's brother.
- Who did that chemist, the one in the local lab (Trisha worked in last semester), decide to hire?  
Who did that chemist who was in the local lab (Trisha worked in last semester) decide to hire?  
That chemist, the one in the local lab (Trisha worked in last semester), decided to hire an English major.  
That chemist who was in the local lab (Trisha worked in last semester) decided to hire an English major.
- Who did that butcher, the one in the busy shop (Amy visited on Third Avenue), buy his meat from?  
Who did that butcher who was in the busy shop (Amy visited on Third Avenue) buy his meat from?  
That butcher, the one in the busy shop (Amy visited on Third Avenue), bought his meat from local farmers.  
That butcher who was in the busy shop (Amy visited on Third Avenue) bought his meat from local farmers.
- Who did that economist, the one at the conference (Paul attended in Rome), blame for the bank collapse?  
Who did that economist who was at the conference (Paul attended in Rome) blame for the bank collapse?  
That economist, the one at the conference (Paul attended in Rome), blamed Wall Street for the bank collapse.  
That economist who was at the conference (Paul attended in Rome) blamed Wall Street for the bank collapse.
- Who did that taxi driver, the one outside the station (where Mary lost her bags), try to overcharge?

Who did that taxi driver who was outside the station (where Mary lost her bags) try to overcharge?

That taxi driver, the one outside the station (where Mary lost her bags), tried to overcharge Amy.

That taxi driver who was outside the station (where Mary lost her bags) tried to overcharge Amy.

7. Who did that fast swimmer, the one at the beach (George visited last August), challenge to a race?

Who did that fast swimmer who was at the beach (George visited last August) challenge to a race?

That fast swimmer, the one at the beach (George visited last August), challenged Louis to a race.

That fast swimmer who was at the beach (George visited last August) challenged Louis to a race.

8. Who did that contractor, the one at the local Starbucks (Liz goes to all the time), build a house for?

Who did that contractor who was at the local Starbucks (Liz goes to all the time) build a house for?

That contractor, the one at the local Starbucks (Liz goes to all the time), built a house for the mayor.

That contractor who was at the local Starbucks (Liz goes to all the time) built a house for the mayor.

9. Who did that unhappy customer, the one at the organic shop (Zach gets food from), complain to yesterday?

Who did that unhappy customer who was at the organic shop (Zach gets food from) complain to yesterday?

That unhappy customer, the one at the organic shop (Zach gets food from), complained to the manager yesterday.

That unhappy customer who was at the organic shop (Zach gets food from) complained to the manager yesterday.

10. Who did that developer, the one at the famous firm (Jennifer respects a lot), design a building for?

Who did that developer who was at the famous firm (Jennifer respects a lot) design a building for?

That developer, the one at the famous firm (Jennifer respects a lot), designed a building for Bill Gates.

That developer who was at the famous firm (Jennifer respects a lot) designed a building for Bill Gates.

11. Who did that defendant, the one in the recent trial (Kelly watched on TV), use as a character witness?

Who did that defendant who was in the recent trial (Kelly watched on TV) use as a character witness?

That defendant, the one in the recent trial (Kelly watched on TV), used the janitor as a character witness.

That defendant who was in the recent trial (Kelly watched on TV) used the janitor as a character witness.

12. Who did that designer, the one at the fancy shop (Ralph buys perfume from), hire as a salesperson?

Who did that designer who was at the fancy shop (Ralph buys perfume from) hire as a salesperson?

That designer, the one at the fancy shop (Ralph buys perfume from), hired Jacob as a salesperson.

That designer who was at the fancy shop (Ralph buys perfume from) hired Jacob as a salesperson.

13. Who did that chef, the one from the Japanese restaurant (Emily eats sushi at), invite into the kitchen?

Who did that chef who was from the Japanese restaurant (Emily eats sushi at) invite into the kitchen?

That chef, the one at the Japanese restaurant (Emily eats sushi at), invited the customers into the kitchen.

That chef who was at the Japanese restaurant (Emily eats sushi at) invited the customers into the kitchen.

14. Who did that veteran, the one at the anti-war lecture (Mark attended last night), praise for his activism?

Who did that veteran who was at the anti-war lecture (Mark attended last night) praise for his activism?

That veteran, the one at the anti-war lecture (Mark attended last night), praised Joseph for his activism.

That veteran who was at the anti-war lecture (Mark attended last night) praised Joseph for his activism.

15. Who did that cute barista, the one at the cafe (Heather visits every morning), give a free coffee to?

Who did that cute barista who was at the cafe (Heather visits every morning) give a free coffee to?

That cute barista, the one at the cafe (Heather visits every morning), gave a free coffee to the first customer.

That cute barista who was at the cafe (Heather visits every morning) gave a free coffee to the first customer.

16. Who did that waitress, the one at the Chinese restaurant (Louise dines in every week), teach Chinese to?

Who did that waitress who was at the Chinese restaurant (Louise dines in every week) teach Chinese to?

That waitress, the one at the Chinese restaurant (Louise dines in every week), taught Chinese to Philip.

That waitress who was at the Chinese restaurant (Louise dines in every week) taught Chinese to Philip.

17. Who did that policeman, the one at the intersection (Eric lives near), pull over for speeding?

Who did that policeman who was at the intersection (Eric lives near) pull over for speeding?

That policeman, the one at the intersection (Eric lives near), pulled a congressman over for speeding.

That policeman who was at the intersection (Eric lives near) pulled a congressman over for speeding.

18. Who did that detective, the one on the cop show (James watches regularly), try to arrest?

Who did that detective who was on the cop show (James watches regularly) try to arrest?

That detective, the one on the cop show (James watches regularly), tried to arrest an innocent bystander.

That detective who was on the cop show (James watches regularly) tried to arrest an innocent bystander.

19. Who did that gardener, the one at the large estate (Wendy toured in July), design a hedge maze for?

Who did that gardener who was at the large estate (Wendy toured in July) design a hedge maze for?

That gardener, the one at the large estate (Wendy toured in July), designed a hedge maze for a rich politician.

That gardener who was at the large estate (Wendy toured in July) designed a hedge maze for a rich politician.

20. Who did that famous professor, the one from the economics department (Frank got his degree from), try to blame for the bank crisis?

Who did that famous professor who was from the economics department (Frank got his degree from) try to blame for the bank crisis?

That famous professor, the one from the economics department (Frank got his degree from), tried to blame Congress for the bank crisis.

That famous professor who was from the economics department (Frank got his degree from) tried to blame Congress for the bank crisis.

21. Who did that artist, the one at the museum (Bill visited last week), create a sculpture for?

Who did that artist who was at the museum (Bill visited last week) create a sculpture for?

That artist, the one at the museum (Bill visited last week), created a sculpture for the courthouse.

That artist who was at the museum (Bill visited last week) created a sculpture for the courthouse.

22. Who did that student, the one in the art class (Lucy teaches on Sunday), paint a picture of?

Who did that student who was in the art class (Lucy teaches on Sunday) paint a picture of?

That student, the one in the art class (Lucy teaches on Sunday), painted a picture of Mickey Mouse.

That student who was in the art class (Lucy teaches on Sunday) painted a picture of Mickey Mouse.

23. Who did that politician, the one caught in the scandal (CNN reported this morning), try to bribe?

Who did that politician who was caught in the scandal (CNN reported this morning) try to bribe?

That politician, the one caught in the scandal (CNN reported this morning), tried to bribe England's ambassador.

That politician who was caught in the scandal (CNN reported this morning) tried to bribe England's ambassador.

24. Who did that plumber, the one from the union (Rodney was a member of), install a toilet for?

Who did that plumber who was from the union (Rodney was a member of) install a toilet for?

That plumber, the one from the union (Rodney was a member of), installed a toilet for the new neighbours.

That plumber who was from the union (Rodney was a member of) installed a toilet for the new neighbours.

## Appendix 2

The experimental stimuli for Experiment 3 are listed below. Object modifier conditions are presented first in their parenthetical and restrictive forms, followed by subject modifier conditions. The additional length for *long* conditions is presented in parentheses.

1. *Object, Parenthetical*: The evil man tried to intimidate that waitress, the one who was on the cruise (Mary took to the Pacific Islands).

*Object, Restrictive*: The evil man tried to intimidate that waitress who was on the cruise (Mary took to the Pacific Islands).

*Subject, Parenthetical*: That evil man, the one who was on the cruise (Mary took to the Pacific Islands), tried to intimidate the waitress.

*Subject, Restrictive*: That evil man who was on the cruise (Mary took to the Pacific Islands) tried to intimidate the waitress.

2. The talented student ended up dating that new girl, the one who was at the big party (John attended at the Fine Arts Center).

The talented student ended up dating that new girl who was at the big party (John attended at the Fine Arts Center).

That talented student, the one who was at the big party (John attended at the Fine Arts Center), ended up dating the new girl.

That talented student who was at the big party (John attended at the Fine Arts Center) ended up dating the new girl.

3. The chemist decided to hire that Biology major, the one who was from the new lab (Trisha worked in last semester).

The chemist decided to hire that Biology major who was from the new lab (Trisha worked in last semester).

That chemist, the one who was from the new lab (Trisha worked in last semester), decided to hire the Biology major.

That chemist who was from the new lab (Trisha worked in last semester) decided to hire the Biology major.

4. The economist made fun of that banker, the one who was at the conference (Paul attended in Rome).

The economist made fun of that banker who was at the conference (Paul attended in Rome).

That economist, the one who was at the conference (Paul attended in Rome), made fun of the banker.

That economist who was at the conference (Paul attended in Rome) made fun of the banker.

5. The taxi driver asked for directions from that policeman, the one who was outside the station (where Mary lost her bags).

The taxi driver asked for directions from that policeman who was outside the station (where Mary lost her bags).

That taxi driver, the one who was outside the station (where Mary lost her bags), asked for directions from the policeman.

That taxi driver who was outside the station (where Mary lost her bags) asked for directions from the policeman.

6. The fast swimmer wanted to race that lifeguard, the one who was at the public beach (George visited last week).

The fast swimmer wanted to race that lifeguard who was at the public beach (George visited last week).

That fast swimmer, the one who was at the public beach (George visited last week), wanted to race the lifeguard.

That fast swimmer who was at the public beach (George visited last week) wanted to race the lifeguard.

7. The contractor built a house for that strange townie, the one who was at the local Starbucks (Liz goes to all the time).

The contractor built a house for that strange townie who was at the local Starbucks (Liz goes to all the time).

That contractor, the one who was at the local Starbucks (Liz goes to all the time), built a house for the strange townie.

That contractor who was at the local Starbucks (Liz goes to all the time) built a house for the strange townie.

8. The developer works with that lawyer, the one who was at the famous firm (Jennifer respects a lot).

The developer works with that lawyer who was at the famous firm (Jennifer respects a lot).

That developer, the one who was at the famous firm (Jennifer respects a lot), works with the lawyer.

That developer who was at the famous firm (Jennifer respects a lot) works with the lawyer.

9. The defendant called in that expert witness, the one who was in the recent trial (Kelly watched on TV).

The defendant called in that expert witness who was in the recent trial (Kelly watched on TV).

That defendant, the one who was in the recent trial (Kelly watched on TV), called in the expert witness.

That defendant who was in the recent trial (Kelly watched on TV) called in the expert witness.

10. The designer dated that sales clerk, the one who was at the fancy shop (Ralph buys perfume from).

The designer dated that sales clerk who was at the fancy shop (Ralph buys perfume from).

That designer, the one who was at the fancy shop (Ralph buys perfume from), dated the sales clerk.

That designer who was at the fancy shop (Ralph buys perfume from) dated the sales clerk.

11. The chef insulted that rich customer, the one who was at the Japanese restaurant (Emily eats sushi at).

The chef insulted that rich customer who was at the Japanese restaurant (Emily eats sushi at).

That chef, the one who was at the Japanese restaurant (Emily eats sushi at), insulted the rich customer.

That chef who was at the Japanese restaurant (Emily eats sushi at) insulted the rich customer.

12. The veteran met that labour organiser, the one who was at the anti-war lecture (Mark attended last night).

The veteran met that labour organiser who was at the anti-war lecture (Mark attended last night).

That veteran, the one who was at the anti-war lecture (Mark attended last night), met the labour organiser.

That veteran who was at the anti-war lecture (Mark attended last night) met the labour organiser.

13. The policeman flirted with that cute barista, the one who was at the local café (Heather visits every morning).

The policeman flirted with that cute barista who was at the local café (Heather visits every morning).

That policeman, the one who was at the local café (Heather visits every morning), flirted with the cute barista.

That policeman who was at the local café (Heather visits every morning) flirted with the cute barista.

14. The waitress identified that careless chef, the one who was at the Chinese restaurant (Louise dines in every week).

The waitress identified that careless chef who was at the Chinese restaurant (Louise dines in every week).

That waitress, the one who was at the Chinese restaurant (Louise dines in every week), identified the careless chef.

That waitress who was at the Chinese restaurant (Louise dines in every week) identified the careless chef.

15. The detective met that gorgeous actress, the one who was on the cop show (James watches regularly).

The detective met that gorgeous actress who was on the cop show (James watches regularly).

That detective, the one who was on the cop show (James watches regularly), met the gorgeous actress.

That detective who was on the cop show (James watches regularly) met the gorgeous actress.

16. The famous professor praised that economist, the one who was from the economics department (Frank got his degree from).

The famous professor praised that economist who was from the economics department (Frank got his degree from).

That famous professor, the one who was from the economics department (Frank got his degree from), praised the economist.

That famous professor who was from the economics department (Frank got his degree from) praised the economist.

17. The student met that art critic, the one who was in the art class (Lucy teaches on Sunday).

The student met that art critic who was in the art class (Lucy teaches on Sunday).

That student, the one who was in the art class (Lucy teaches on Sunday), met the art critic.

That student who was in the art class (Lucy teaches on Sunday) met the art critic.

18. The politician tried to bribe that ambassador, the one who was caught in the big scandal (CNN reported this morning).

The politician tried to bribe that ambassador who was caught in the big scandal (CNN reported this morning).

That politician, the one who was caught in the big scandal (CNN reported this morning), tried to bribe the ambassador.

That politician who was caught in the big scandal (CNN reported this morning) tried to bribe the ambassador.

19. The plumber met that organiser, the one who was from the union (Rodney was a member of).

The plumber met that organiser who was from the union (Rodney was a member of).

That plumber, the one who was from the union (Rodney was a member of), met the organiser.

That plumber who was from the union (Rodney was a member of) met the organiser.

20. The landscape architect greeted that famous gardener, the one who was at the large estate (Wendy toured in July).

The landscape architect greeted that famous gardener who was at the large estate (Wendy toured in July).

That landscape architect, the one who was at the large estate (Wendy toured in July), greeted the famous gardener.

That landscape architect who was at the large estate (Wendy toured in July) greeted the famous gardener.

21. The artist praised that new light sculptor, the one who was featured at the Smith museum exhibit (Bill visited last week).

The artist praised that new light sculptor who was featured at the Smith museum exhibit (Bill visited last week).

That artist, the one who was featured at the Smith museum exhibit (Bill visited last week), praised the new light sculptor.

That artist who was featured at the Smith museum exhibit (Bill visited last week) praised the new light sculptor.

22. The policeman monitored that drug lord, the one who hangs out at the intersection (Eric lives near).

The policeman monitored that drug lord who hangs out at the intersection (Eric lives near).

That policeman, the one who hangs out at the intersection (Eric lives near), monitored the drug lord.

That policeman who hangs out at the intersection (Eric lives near) monitored the drug lord.

23. The unhappy herbalist complained about that clerk, the one who works at the organic shop (Zach gets food from).

The unhappy herbalist complained about that clerk who works at the organic shop (Zach gets food from).

That unhappy herbalist, the one who works at the organic shop (Zach gets food from), complained about the clerk.

That unhappy herbalist who works at the organic shop (Zach gets food from) complained about the clerk.

24. The actor signalled to that assistant, the one who was always on the set (Marta designed).

The actor signalled to that assistant who was always on the set (Marta designed).

That actor, the one who was always on the set (Marta designed), signalled to the assistant.

That actor who was always on the set (Marta designed) signalled to the assistant.