EFFECTS OF SENTENCE STRUCTURE ON PROCESSING OF COMPLEX SEMANTIC EXPRESSIONS

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ABSTRACT

Matthew W. Lowder: Effects of Sentence Structure on
Processing of Complex Semantic Expressions
(Under the direction of Peter C. Gordon)

Seven eye-tracking-while-reading experiments were conducted to examine how the processing of complex semantic expressions is modulated by changes to sentence structure. The results show that inanimate subject-verb integration (e.g., *The pistol injured the cowboy*), metonymy (e.g., *The journalist offended the college*), and complement coercion (e.g., *The secretary began the memo*) impose a processing cost on the reader when the critical constituents appear together the same clause. In contrast, processing difficulty is reduced or eliminated completely when there is a distant structural relationship between the constituents that convey the complex meaning (e.g., *The pistol that injured the cowboy; The journalist offended the honor of the college; The memo that the secretary began*). Two corpus analyses demonstrate that there is not a straightforward relationship between reductions in online processing difficulty due to sentence structure and frequency patterns in samples of naturally occurring language. A theoretical framework is proposed that conceptualizes the processing of a variety of complex semantic expressions as stemming from a similar processing stage reflecting the need to detect and resolve a semantic mismatch, although the precise mechanisms underlying this process likely vary depending on the specific type of semantic expression. Reductions in processing difficulty due to structural separation reflect linguistic deemphasis of a complex semantic relationship and the reader's tendency to process this deemphasized relationship at a shallow or underspecified level.

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CHAPTER 1: Introduction

Two very different types of sentence complexities have been documented in the psycholinguistic literature. On the one hand, a sentence may be considered *semantically complex*, as when an expression requires a figurative interpretation (e.g., *The gentleman read Dickens*). On the other hand, a sentence may be considered *syntactically complex*, as when a single expression is represented in multiple clauses within the same sentence (e.g., *The reporter that the senator attacked admitted the error*). Although a great deal of research has examined separately how semantic and syntactic manipulations influence sentence processing, very little work has examined how processing is influenced when these two sources of complexity combine in the same sentence.

This dissertation includes three empirical papers, each of which investigates the effects of sentence structure on the processing of a different type of complex semantic expression: inanimate subject-verb integration (e.g., *The pistol injured the cowboy*; Lowder & Gordon, 2012), metonymy (e.g., *The journalist offended the college*; Lowder & Gordon, 2013), and complement coercion (e.g., *The secretary began the memo*; Lowder & Gordon, under review). Together, these three papers present the results of seven eye-tracking-while-reading experiments demonstrating that readers experience enhanced processing difficulty with these complex expressions (compared to control sentences) when the critical constituents appear together in the same clause of the sentence. In contrast, difficulty is substantially reduced or eliminated altogether when one of the critical constituents appears in the main clause of the sentence and another is embedded in a relative clause or some other adjunct phrase.

As will be discussed in the chapters below, the psycholinguistic literature on inanimate subject-verb integration, metonymy, complement coercion, and other types of complex semantic expressions has tended to characterize these phenomena as distinct from one another without considering whether they share any similar processing mechanisms. Notably, these expressions all involve some sort of semantic mismatch. In these expressions, a semantic mismatch occurs when an inanimate subject must be integrated with an action verb that requires an animate subject (e.g., *The pistol injured the cowboy*), when a psychological verb that requires an experiencer object is paired with an object that refers to a non-human place (e.g., *The journalist offended the college*), or when a verb that requires an event-denoting noun is paired with a noun that instead refers to an entity (e.g., *The secretary began the memo*). In trying to characterize the processing of these various expressions, a plausible account might be the *standard pragmatic model* or *indirect access model* (e.g., Clark & Lucy, 1975; Grice, 1975; Janus & Bever, 1985; Searle, 1979), which was originally proposed as an explanation of how figurative language is processed. According to this account, the comprehender computes the literal meaning of an expression using the stored meanings of lexical entries, which results in a "defective" (Searle, 1979) interpretation in the case of figurative language, leading the comprehender to search for an alternative meaning. A focus of this dissertation involves determining how processing accounts such as the indirect access model (among others), which were originally developed to explain one semantic phenomenon, may also be useful in explaining the processing of semantic mismatches more broadly. This involves gaining a better understanding of which processing mechanisms are common among various complex semantic expressions in general and which depend instead on the specific type of expression under consideration.

The finding that the processing of several types of complex semantic expressions is modulated by sentence structure in similar ways supports the notion that these expressions may share a similar processing mechanism. Indeed, a variety of linguistic and psycholinguistic perspectives have previously suggested that the relations between different parts of a sentence are processed to varying degrees, with the depth of processing depending to a large extent on the structure of the sentence (e.g., Baker & Wagner, 1987; Ferreira, Bailey, & Ferraro, 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). It may be the case that structural separation of a complex semantic expression reduces the likelihood that the comprehender will detect the semantic mismatch. Alternatively, structural separation may influence the process of searching for an alternative meaning. These possibilities are considered in detail in the chapters that follow.

The General Discussion sections of Lowder and Gordon (2012) and Lowder and Gordon (2013) outline various implications that the obtained results have for inanimate subject-verb integration and metonymy, respectively. The General Discussion section of Lowder and Gordon (under review) discusses the implications of the obtained results for complement coercion, but also sketches a theoretical framework that explains the processing of complex semantic expressions more generally and possible reasons that their processing is modulated by structural manipulations. Following Lowder and Gordon (under review), I present the results of two corpus analyses as a new source of empirical evidence. The first analysis examines whether sentence structure influences the frequency of literal versus figurative uses of metonyms in naturally occurring language. The second examines whether event-selecting verbs are more likely to combine with an entity-denoting noun phrase in an object-extracted relative clause than in a subject-extracted relative clause. These corpus patterns are then discussed in light of the

experimental results obtained in Lowder and Gordon (2013, under review). Finally, I conclude by expanding on the theoretical points outlined in Lowder and Gordon (under review), discussing the implications of the corpus results, and offering some possible directions for future research.

CHAPTER 2: Lowder and Gordon (2012)[1]

The expressive power of human language rests in part on its ability to represent multiple relationships between different entities in a single sentence with more than one clause. The process of understanding such complex sentences requires that this representation be built incrementally as the words of a sentence are read or heard, even though the relationships between the meanings conveyed by those words may not be clear until all the words of a sentence are encountered. Research investigating the cognitive processes underlying the comprehension of complex sentences has focused a great deal on sentences containing subject-extracted and object-extracted relative clauses (RCs). In a subject RC (SRC), as in (1a), the head noun phrase (NP) is the subject of the RC, whereas in an object RC (ORC), as in (1b), the head NP is the object of the RC. These two sentences contain the exact same words, just in a different order, yet ORCs have been shown to impose greater processing difficulty than SRCs on a wide variety of tasks (e.g., Caplan, Alpert, & Waters, 1998; Caramazza & Zurif, 1976; Ford, 1983; Holmes & O'Regan, 1981; Just, Carpenter, Keller, Eddy, & Thulborn, 1996; King & Just, 1991; Wanner & Maratsos, 1978).

1a. The reporter that injured the senator persuaded the members of the jury.

1b. The reporter that the senator injured persuaded the members of the jury.

Although different types of cognitive mechanisms have been implicated as contributing to the difficulty of incremental interpretation of complex sentences (for a review see Gordon &

[1] This chapter previously appeared as an article in the *Journal of Memory and Language*. The original citation is as follows: Lowder, M. W., & Gordon, P. C. (2012). The pistol that injured the cowboy: Difficulty with inanimate subject-verb integration is reduced by structural separation. *Journal of Memory and Language, 66*, 819-832.

Lowder, in press), it is clear that mechanisms that find meaningful relationships between parts of a sentence can offset complexity effects when those relationships are easy to establish. For example, King and Just (1991) demonstrated that the difficulty associated with processing an ORC sentence with arbitrary noun-verb pairings (e.g., *The robber that the fireman detested watched the program*) was substantially reduced when there were inherent semantic relationships between the nouns and verbs (e.g., *The robber that the fireman rescued stole the jewelry*).

The factors that facilitate establishment of meaningful relationships between parts of a complex sentence do not depend completely on there being specific relationships between nouns and verbs at the level of events that are likely to occur (as in *fireman rescued* and *robber stole* in the King and Just example). Instead, it has been argued that they include relationships at the level of thematic roles (Gennari & MacDonald, 2008, 2009; Mak, Vonk, & Schriefers, 2002, 2006; Traxler, Morris, & Seely, 2002; Traxler, Williams, Blozis, & Morris, 2005). For example, Traxler et al. (2002, 2005) varied the animacy of the two critical NPs in RC sentences, as in (2). They found that ORCs with an inanimate head NP and an animate embedded NP (2b) were as easy to process as SRCs (2c)-(2d), but that ORCs with an animate head NP and an inanimate embedded NP (2a) were more difficult than the other three conditions. This difficulty emerged not only on the relative clause itself, but also extended to the matrix verb.

2a. The cowboy that the pistol injured was known to be unreliable.

2b. The pistol that the cowboy concealed was known to be unreliable.

2c. The cowboy that concealed the pistol was known to be unreliable.

2d. The pistol that injured the cowboy was known to be unreliable.

As can be seen in (2), the experimental materials used by Traxler et al. (2002, 2005) compared conditions in which each sentence contains both an animate and an inanimate NP.

This configuration is problematic because it is impossible to determine whether the greater difficulty found between the ORC sentences in (2a) and (2b) is caused by the animacy of NP1, the animacy of NP2, or a combination of both. Determining the source of the processing difficulty is complicated further by the need to use different embedded verbs in the two types of ORC sentences. While previous research on the role of animacy in RC processing has typically varied the animacy of NP1 and NP2 together, the role of the animacy of NP2 on the processing difficulty found in ORCs can be isolated by varying the animacy of NP2 and holding both NP1 and the embedded verb constant as shown in (3).

3a. The sheriff that the cowboy injured persuaded the members of the jury.

3b. The sheriff that the pistol injured persuaded the members of the jury.

The contrast between (3a) and (3b) suggests that at least part of the reason for the advantage in understanding ORCs with animate NP2s as compared to inanimate NP2s is local to the processing of the embedded clause rather than to processing the embedded clause in relation to information in the main clause. The embedded verb may be easier to interpret when there is an animate NP2 (e.g., *cowboy injured*) than when there is an inanimate NP2 (e.g., *pistol injured*). A local difference in ease of processing could arise for several reasons. For example, it has been suggested that an inanimate subject NP may force a non-prototypical assignment of thematic roles (instrument rather than agent; Cruse, 1973; Dowty, 1991; Fillmore, 1968; Schlesinger, 1989; Wolff, Jeon, Klettke, & Li, 2010; Wolff, Jeon, & Li, 2009). Difficulty might also arise from additional processing steps required for enriched composition (McElree, Traxler, Pickering, Seely, & Jackendoff, 2001; Traxler, Pickering, & McElree, 2002; Pustejovsky, 1995), or from the need to access literal interpretations prior to figurative interpretations (Grice, 1975; Searle, 1979). Thus, a variety of types of evidence suggest that local interpretation of the inanimate

noun and verb paired within the embedded ORC might account for all or part of previously reported effects of animacy on the ORC-SRC asymmetry in ease of processing. However, this possibility is by no means certain, as other psycholinguistic research supports the notion that interpretations that are metaphorical (Glucksberg, 1991; 2003) or metonymic (Frisson & Pickering, 1999; Humphrey, Kemper, & Radel, 2004) are accessed as quickly as literal interpretations, an alternative that suggests that there would be no local difference in ease of processing the inanimate-noun and verb pairings within the embedded ORC.

The hypothesis that a local effect of NP2 animacy accounts for results previously attributed to the effect of animacy on relative-clause processing *per se* (e.g., 2a vs. 2b) is challenged further by evidence that the animacy of NP1 has little or no effect on the ease of processing within SRC sentences (e.g., 2c vs. 2d). Such an effect might be expected since the head of an SRC is the subject of the embedded verb, yielding pairings of inanimate NP1 with embedded verb (see 2d) that match those found in the ORC constructions with an inanimate NP2 (see 2a). If interpretation of the pairings of inanimate nouns and verbs used in these studies imposes a local processing cost, then the absence of such an effect for the SRC sentences must be explained. A variety of types of psycholinguistic evidence indicates that the relations between different parts of a sentence are processed to varying degrees, with the depth of processing depending greatly on the structure of the sentence (Baker & Wagner, 1987; Bredart & Modolo, 1988; Ferreira, Bailey, & Ferraro, 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). This suggests that processing of the meanings of an NP and a verb may occur at a deeper level when the expressions are within the same clause as compared to when they are separated by a clause boundary such as when an SRC modifies an inanimate head noun (e.g., 3d).

Experiment 1

This experiment examined the processing of ORCs when the embedded NP was animate versus inanimate. The ORCs used by Traxler et al. (2005, Experiment 3) were adapted for the current experiment so as to allow a careful examination of the locus of this difficulty. Traxler et al.'s sentences contained embedded nouns that differed in animacy, but the experimental contrasts also involved different embedded verbs (e.g., *pistol injured* versus *cowboy concealed*; see 3a-3b) and different head nouns. Accordingly, these materials were altered so that the only difference between the two ORCs was the animacy of the embedded NP (see 4b-4c). In addition, we created an SRC version of each sentence (4a). Thus, a comparison of condition (4a) with (4b) should reveal an ORC-SRC processing difference, whereas a comparison of (4b) and (4c) allows examination of the locus of the processing difficulty associated with integrating an inanimate versus animate subject with a verb. We refer to these three conditions as SRC, ORC-Animate, and ORC-Inanimate, respectively.

4a. The sheriff that injured the cowboy persuaded the members of the jury. (SRC)

4b. The sheriff that the cowboy injured persuaded the members of the jury. (ORC-Animate)

4c. The sheriff that the pistol injured persuaded the members of the jury. (ORC-Inanimate)

Based on the findings of previous work (Gennari & MacDonald, 2008; Traxler et al., 2002, 2005), we expected the ORC-Inanimate condition to be more difficult than the ORC-Animate condition. With regard to the locus of this effect, two outcomes are possible. First, it is possible that the difficulty associated with the ORC-Inanimate condition will appear in a broad region of the sentence, perhaps beginning early in the RC and continuing on to the matrix verb.

This pattern would provide support for the idea that NP animacy influences RC processing, as a large body of literature has demonstrated that the difficulty associated with processing an ORC affects reading times for several words in the sentence (e.g., Ford, 1983; Gordon, Hendrick, & Johnson, 2001, 2004; Gordon, Hendrick, Johnson, & Lee, 2006; Holmes & O'Regan, 1981; Johnson, Lowder, & Gordon, 2011; King & Just, 1991; Traxler et al., 2002, 2005; see Gordon & Lowder, in press, for review). Alternatively, it is possible that the difficulty associated with the ORC-Inanimate condition is unrelated to broad RC-level effects, but instead emerges due to the local difficulty of integrating an inanimate noun with an action verb, such as *pistol injured*.

The possibility of using an inanimate noun as the subject of an action verb was noted by Fillmore (1968), who observed that an instrument that appears as part of an adjunct phrase in a causal construction (e.g., *John broke the window with a hammer*) can also often appear as the external argument of the verb (e.g., *A hammer broke the window*; see also Cruse, 1973). Inanimate NPs vary in their acceptability as "causers," and verbs vary in the ease with which they can be paired with inanimate causers. For example, Schlesinger (1989) noted that *The dishwasher cleaned the dishes* sounds more natural than *The rag cleaned the dishes*, perhaps because machines make better agents than do rags. He further noted that *The bullet killed the president* is acceptable while *The bullet murdered the president* is anomalous, because the verb *murder* requires that the subject possess intention (see also Wolff et al., 2010). Dowty (1991) proposed that the thematic roles assigned to the arguments of a verb tend to possess certain prototypical features falling into one of two broad categories, which he terms Proto-Agent and Proto-Patient. Dowty lists several features belonging to a Proto-Agent, which include the ability to change the state of another participant and the ability to initiate movement. This perspective

may help explain why certain inanimate NPs are more acceptable than others as the subject of an action verb.

In addition, the presence of an inanimate NP as the subject of an action verb might require a process of figurative interpretation. For example, in (4c), a *pistol* is incapable of performing the action *injure* on its own. Thus, one may infer here that the tool is being used as a referential expression to stand for the unnamed animate agent (e.g., *the one who used the pistol*). This suggests a type of *metonymic* construction, where some salient characteristic of an entity refers to the entity as a whole. Research on language processing provides conflicting perspectives about whether literal and figurative meanings are processed differently. While some models propose that a literal interpretation must be accessed before a figurative interpretation (e.g., Grice, 1975; Searle, 1979), others propose that literal and figurative interpretations can be accessed in parallel (e.g., Glucksberg, 1991, 2003). Although a great deal of work has been devoted to better understanding the processing of figurative language in general (e.g., Gerrig & Healy, 1983; Gibbs, 1980, 1986; Gibbs, Bogdanovich, Sykes, & Barr, 1997; Inhoff, Lima, & Carroll, 1984; Onishi & Murphy, 1993; Ortony, Schallert, Reynolds, & Antos, 1978; Shinjo & Myers, 1987), very little work has examined the processing of metonymy specifically. One prominent exception is Frisson and Pickering (1999), who measured eye movements while participants read sentences containing place-for-institution metonyms (e.g., *That blasphemous woman had to answer to the convent*) and place-for-event metonyms (e.g., *A lot of Americans protested during Vietnam*). Frisson and Pickering showed that processing these metonyms was just as easy as processing the same words when they were used in their literal sense, thus providing evidence for parallel access of the literal and figurative interpretations.

Expressions such as *pistol injured* are closer in form to what Lakoff and Johnson (1980) termed object-for-user metonyms (e.g., *The gun he hired wanted fifty grand*) than to the place-for-institution and place-for-event metonyms studied by Frisson and Pickering (1999). Object-for-user metonyms were studied by Gibbs (1990), who found greater whole-sentence reading times when the sentence subject was metonymic (e.g., *scalpel* to refer to *surgeon*) compared to both a literal condition (e.g., *doctor*) and a metaphoric condition (e.g., *butcher*), suggesting some processing cost associated with figurative interpretation. Whereas the object-for-user metonyms studied by Gibbs were constructed so that the metonym referred to a person (e.g., *The scalpel was sued for malpractice*), constructions like (4c) can be understood either by inferring that the instrument represents a person (e.g., *pistol* to refer to *shooter*), or by inferring that the instrument represents an event (e.g., *someone's shooting of the pistol*). This latter perspective has been discussed by Pustejovsky (1995) in his comparison of the two sentences presented in (5). Here, the verb *kill* specifies an action, and so it selects for an animate NP as its subject. This requirement is satisfied in (5a), but not in (5b). Specifically, Pustejovsky proposes that the inanimate subject in (5b) represents a type of metonymic construction that requires an additional process of deep interpretation, which he called *coercion*. That is, Pustejovsky proposes that the inanimate entity in (5b) makes sense as the subject of the sentence because it is coerced from an object (e.g., *the gun*) into an event involving an animate agent (e.g., *someone's shooting of the gun*).

5a. John killed Mary.

5b. The gun killed Mary.

Evidence that coercion incurs a processing cost has been found for NPs that syntactically appear as direct objects and which refer to objects when they follow verbs that require an event

complement as compared to those that take a direct object (e.g., *The author began/wrote the book*; McElree et al., 2001; Traxler et al., 2002). However, psycholinguistic evidence of coercion has not previously been reported for the conditions to be studied here – subject NPs that do not meet animacy specifications of verbs.

In sum, multiple linguistic and psycholinguistic approaches suggest that subject-verb integration should be more difficult for inanimate than animate nouns. Previous studies on animacy and relative-clause processing have provided evidence that there is difficulty associated with embedding an inanimate NP within an ORC and that this difficulty contributes to the overall processing of the RC. However, the covariation of animacy configurations and different embedded verbs used by these studies make this interpretation problematic. Experiment 1 was designed to more carefully isolate the locus of processing difficulty by comparing ORCs where the only variation across ORC conditions was in the animacy of the embedded noun.

Method

Participants. Twenty-four students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials. Each participant was presented with 30 experimental sentences and 94 filler sentences. The 30 experimental sentences were adapted from Traxler et al. (2005, Experiment 3). These materials were modified to include a new animate noun that served as NP1 in all three versions of each sentence (e.g., *sheriff*; see 4a-4c). The embedded verb, animate NP2, and inanimate NP2 were all taken directly from Traxler et al. Importantly, Traxler et al. had carefully balanced the animate and inanimate NP2s for length and frequency. The matrix verb and the remainder of the sentence were modified such that the meaning could feasibly apply to

either of the two animate NPs or the inanimate NP. (See Appendix A for full set of experimental stimuli).

4a. The sheriff that injured the cowboy persuaded the members of the jury. (SRC)

4b. The sheriff that the cowboy injured persuaded the members of the jury. (ORC-Animate)

4c. The sheriff that the pistol injured persuaded the members of the jury. (ORC-Inanimate)

In addition to controlling for frequency of N2, we computed bigram (word-pair) frequencies of N2 and the embedded verb for the ORC-Animate versus ORC-Inanimate conditions (e.g., *cowboy injured* vs. *pistol injured*) using two different corpora: the Corpus of Contemporary American English (COCA; Davies, 2008) and the Google Terabyte N-Gram corpus (Brants & Franz, 2006). These corpora give highly consistent estimates of the relative frequency of the critical words in the study, showing the following Spearman rank-order correlations: embedded animate nouns (rho = .92, $p < .001$), embedded inanimate nouns (rho = .89, $p < .001$), and embedded verbs (rho = .90, $p < .001$). COCA provided bigram frequencies for 25 out of the 60 critical noun-verb pairs in the materials, whereas Google N-Gram provided bigram frequencies for 39 of the 60 pairs. This difference is likely due to COCA being based on a smaller sample of text (425 million words) as compared to Google N-Gram (approximately 1,000,000,000,000 words). The fact that over one third of the noun-verb pairs were not observed even in Google N-Gram points to the limitations of using even a very large corpus, one far larger than any individual's life experience with language, to estimate the predictability of a word based on the preceding word. Transitional probabilities, defined as the probability of encountering a particular word, given the preceding word (McDonald & Shillcock, 2003), were

computed from Google N-Gram. These did not differ between the ORC-Animate (.000089) and ORC-Inanimate (.000091) conditions, [$t(37) = 0.02$, $p > .98$], suggesting that predictability of the verb did not vary systematically across conditions based on the animacy of the preceding noun.

Traxler et al. (2005, Experiment 3) had matched their stimuli for plausibility across conditions. In Traxler et al.'s experiment, rating data collected from 12 participants showed no significant differences in mean plausibility ratings between any of the conditions. Although our materials involved only minor changes to Traxler et al.'s materials, we nevertheless wanted to ensure that there were no differences in plausibility among our three conditions. Accordingly, we presented our stimuli, along with filler items, to 15 raters who did not participate in the eye-tracking experiment. The task was to indicate how likely they believed the events described by the sentence were on a scale from 1 (highly unlikely) to 5 (highly likely; e.g., Pickering & Traxler, 1998; Traxler & Pickering, 1996). Each rater saw the sentences in a different random order. Mean plausibility ratings were 3.3 (SRC), 3.2 (ORC-Animate), and 3.2 (ORC-Inanimate). A repeated-measures ANOVA revealed no significant differences across conditions, $F < 1$.

For the eye-tracking experiment, one version of each item was assigned to one of three lists such that no participant saw more than one version of each item. After each sentence, a true/false comprehension question appeared. For the experimental sentences, two-thirds of the comprehension questions asked about the action being described in the RC, whereas the other third asked about the action being described in the main clause (King & Just, 1991). Half of the questions were true and half were false.

Design and procedure. Each experimental session began with four filler sentences. After this warm-up block, the remaining 120 sentences were presented in a different random order for each participant. Participants were instructed to read at a natural pace and to press a

key after reading each sentence. At this point, the comprehension question appeared, and participants pressed one key to answer "true," and another to answer "false."

Participants' eye movements were monitored using an EyeLink 1000 system (SR Research). This device records eye movements using a camera mounted on the table in front of participants, sampling pupil location at a rate of 1000 Hz and parsing the samples into fixations and saccades. After undergoing a procedure that calibrated the eye-tracker, the experimental session began. At the start of each trial, a fixation point was presented on the screen in the location where the first word of the sentence would appear. When the experimenter judged the participant's gaze to be steady on the fixation point, the experimenter pressed a button that made the fixation point disappear and the sentence appear. After reading the sentence, the participant pressed a key, which made the sentence disappear and a comprehension question appear. After the participant responded to the comprehension question, the trial ended and the fixation point for the next trial appeared.

Results

Reading times from all trials were included, regardless of whether the comprehension question was answered correctly. Analysis of the eye-tracking data focused on three standard measures. *Gaze duration* is the sum of all initial fixations on a word or region; it begins when the region is first fixated and ends when gaze is directed away from the region, whether to the left or the right. *Regression-path duration* (also called *go-past time*) is the sum of all fixation durations beginning with the initial fixation on a particular region and ending when the gaze is directed to the right of that region. This measure incorporates both early and later stages of language comprehension and is particularly useful for measuring integration difficulties (Clifton,

Staub, & Rayner, 2007). *Total time* is the sum of all fixations on a word or region. The offline measure of comprehension-question accuracy is also reported.

To assess the RC effect, we report reading times for two regions of interest: the RC and the matrix verb. We chose to analyze the RC as a single region, rather than as a series of individual words, to control for the different word orders of SRCs and ORCs. This region consisted of the three words between the complementizer and the matrix verb. At the matrix verb, the word orders of SRCs and ORCs are identical once again, so this word can be analyzed on its own. In addition to comparing reading times for the RC region and the matrix verb across the three conditions, we were able to take a more fine-grained look at the RC region for the ORC-Animate and ORC-Inanimate conditions.

Table 1 displays reading-time means relevant to RC-level effects. Specifically, we compared reading times for all three conditions at the RC and the matrix verb.

RC region. For each of the three reading-time measures, we conducted a one-way repeated-measures ANOVA comparing the three conditions. Analysis of gaze duration on the RC region revealed no significant differences among the three conditions [$F_1(2, 46) < 1$; $F_2(2, 58) < 1$]. In contrast, significant differences were obtained for regression-path duration [$F_1(2, 46) = 27.69$, $MSE = 35478$, $p < .001$; $F_2(2, 58) = 21.04$, $MSE = 58416$, $p < .001$] and total time [$F_1(2, 46) = 16.31$, $MSE = 58099$, $p < .001$; $F_2(2, 58) = 6.32$, $MSE = 182402$, $p < .005$]. Follow-up comparisons indicated a robust ORC-SRC processing difference, with longer reading times for ORC-Animates compared to SRCs on regression-path duration [$F_1(1, 23) = 43.86$, $MSE = 21782$, $p < .001$; $F_2(1, 29) = 33.02$, $MSE = 36624$, $p < .001$], as well as total time [$F_1(1, 23) = 36.06$, $MSE = 51054$, $p < .001$; $F_2(1, 29) = 10.64$, $MSE = 210967$, $p < .005$]. Similar differences were observed for ORC-Inanimates compared to SRCs on regression-path duration [$F_1(1, 23) =$

32.29, *MSE* = 57191, $p < .001$; $F_2(1, 29) = 35.20$, *MSE* = 65440, $p < .001$], as well as total time [$F_1(1, 23) = 16.50$, *MSE* = 46875, $p < .001$; $F_2(1, 29) = 6.59$, *MSE* = 139593, $p < .02$]. In addition, regression-path durations showed that ORC-Inanimates were read more slowly than ORC-Animates (significant in the subject analysis) [$F_1(1, 23) = 5.30$, *MSE* = 27460, $p < .05$; $F_2(1, 29) = 2.39$, *MSE* = 73185, $p > .13$], whereas there were no significant differences for these two conditions in the total time data (p's > .10). The nature of the difference between the ORC-Animate and ORC-Inanimate conditions is explored in greater detail below.

Table 1
Eye-tracking results of relative-clause effects in Experiment 1. The RC region was defined as the three words after the complementizer and before the matrix verb.

Region of Interest	Condition	Measure (in milliseconds)		
		Gaze	Regression-Path	Total Time
RC region	SRC	509	796	1423
	ORC-Animate	536	1078	1814
	ORC-Inanimate	519	1188	1676
Matrix verb	SRC	284	467	594
	ORC-Animate	306	641	671
	ORC-Inanimate	301	624	672

Matrix Verb. Analysis of gaze durations on the matrix verb showed no significant differences between the three conditions, [$F_1(2, 46) < 1$; $F_2(2, 58) = 1.25$, $p > .25$]. There was, however, a significant difference between the three conditions at the matrix verb for regression-path duration [$F_1(2, 46) = 7.02$, *MSE* = 31566, $p < .01$; $F_2(2, 58) = 5.35$, *MSE* = 46103, $p < .01$] and a significant difference for total time in the subject analysis, but not in the item analysis [$F_1(2, 46) = 4.73$, *MSE* = 10197, $p < .05$; $F_2(2, 58) = 1.87$, *MSE* = 30497, $p > .15$]. Follow-up

comparisons revealed longer reading times for ORC-Animates compared to SRCs for regression-path duration [$F_1(1, 23) = 8.64$, $MSE = 42054$, $p < .01$; $F_2(1, 29) = 9.33$, $MSE = 44517$, $p < .01$], and a similar pattern in the subject analysis for total time [$F_1(1, 23) = 5.36$, $MSE = 13314$, $p < .05$; $F_2(1, 29) = 2.50$, $MSE = 35354$, $p > .10$]. Likewise, there were significant differences between the ORC-Inanimates and the SRCs for regression-path duration [$F_1(1, 23) = 17.48$, $MSE = 17060$, $p < .001$; $F_2(1, 29) = 4.90$, $MSE = 65015$, $p < .05$], and a similar pattern in the subject analysis for total time [$F_1(1, 23) = 8.52$, $MSE = 8593$, $p < .01$; $F_2(1, 29) = 2.55$, $MSE = 32489$, $p > .10$]. In contrast to the ORC-SRC difference, there were no differences between the ORC-Animate and ORC-Inanimate conditions at the matrix verb for either regression-path duration or total time (p's > .60).

Words in the ORC. As noted above, there was a significant difference between the two ORC conditions for regression-path duration on the RC region as a whole. Because these two conditions have identical word orders, it was possible to isolate the locus of this effect with a more fine-grained, word-by-word analysis of the RC region (see Table 2). Comparing regression-path duration for ORC-Animates and ORC-Inanimates at these individual words revealed no differences at the determiner [$F_1(1, 23) < 1$; $F_2(1, 29) < 1$], nor at the embedded noun [$F_1(1, 23) < 1$; $F_2(1, 29) < 1$]. Critically, however, the two conditions differed significantly at the embedded verb, such that ORC-Inanimates were slower than ORC-Animates [$F_1(1, 23) = 8.23$, $MSE = 19026$, $p < .01$; $F_2(1, 29) = 4.05$, $MSE = 55971$, $p = .05$]. This pattern of effects is depicted graphically in Figure 1.[2]

[2] To assess whether the observed animacy difference at the embedded verb could be explained by differences in noun-verb bigram frequency, we conducted a Spearman rank-order correlation comparing mean regression-path durations at the verb and transitional probabilities (see Method section) for the 39 bigram pairs for which Google N-gram contained frequency data. The correlation was not significant (rho = -0.19, $p > .25$). Even so, a closer examination of the data revealed that this non-significant effect was being driven by two items (*burglar shot* and *revolver shot*), both of which had transitional probabilities over twice as large as any of the other items. Removing

Analysis of gaze durations and total times for each word in the RC revealed no significant differences between the ORC-Inanimate and ORC-Animate conditions.

Table 2
Eye-tracking results of animacy effects in Experiment 1.

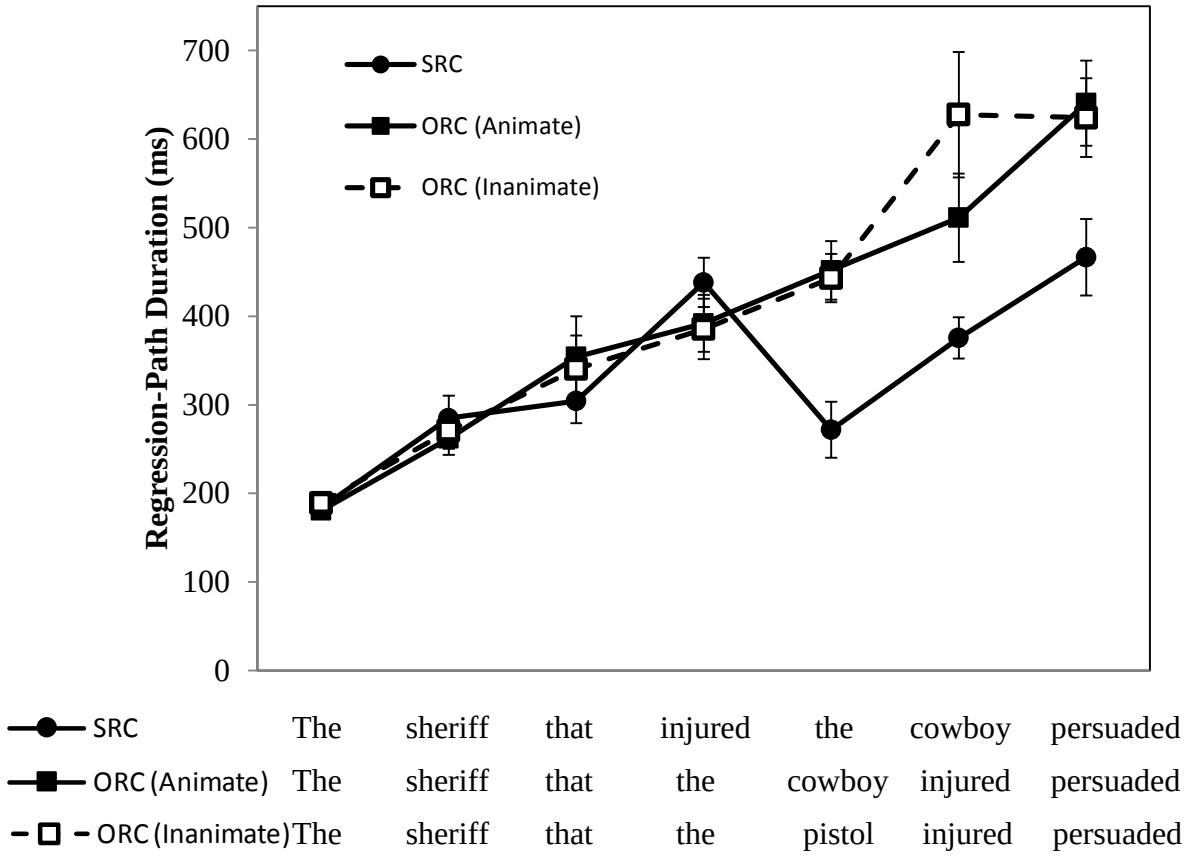
Word	Condition	Measure (in milliseconds)		
		Gaze	Regression-Path	Total Time
Determiner	ORC-Animate	234	392	564
	ORC-Inanimate	206	386	586
Embedded noun	ORC-Animate	234	444	782
	ORC-Inanimate	230	444	678
Embedded verb	ORC-Animate	298	518	847
	ORC-Inanimate	305	633	805

Comprehension-question accuracy. Comprehension questions following four of the sentences had overall accuracy rates lower than 50%. A closer look at these items revealed that the questions were worded ambiguously. These four questions were omitted from the analysis. A one-way repeated-measures ANOVA showed that accuracy rates differed by condition, although this effect was only significant by subjects [$F_1(2, 46) = 4.86$, $MSE = 105$, $p < .05$; $F_2(2, 50) = 2.06$, $MSE = 191$, $p > .13$]. Follow-up comparisons indicated that responses to questions following SRCs were significantly more accurate (93%) than questions following ORC-Animates (87%) [$F_1(1, 23) = 6.41$, $MSE = 66$, $p < .05$, $F_2(1, 28) = 4.41$, $MSE = 137$, $p < .05$].

these two items completely erased any hint of a correlation (rho = -0.05, $p > .77$). Thus, we did not find any evidence for the hypothesis that differences in bigram frequency of N2 and the embedded verb were contributing to the observed differences in reading times at the embedded verb for animate versus inanimate nouns.

There was no difference in accuracy rates between ORC-Animates (87%) and ORC-Inanimates (84%) [$F_1(1, 23) = 1.07$, $MSE = 113$, $p > .31$; $F_2(1, 26) < 1$].

Figure 1
Mean regression-path durations for the three conditions in Experiment 1. Error bars represent the standard error of the mean.



Discussion

The results of Experiment 1 showed greater processing difficulty for ORCs compared to SRCs, as indicated by longer regression-path durations and total times at the RC region of the sentence and at the matrix verb. Also, responses to comprehension questions were less accurate for ORCs than SRCs. These findings are consistent with previous demonstrations of the ORC-SRC processing difference. Comparing regression-path durations on the RC region for the ORC-

Animate and ORC-Inanimate conditions initially suggested that there might be greater RC-related processing difficulty for ORC-Inanimates; however, a word-by-word analysis of this region revealed that this effect emerged entirely at the embedded verb (see Figure 1). In fact, there was no hint of an animacy effect at the matrix verb in any of the three eye-tracking measures used to analyze the data. This pattern shows that integrating an inanimate subject with a verb imposes a local processing cost, but does not contribute to the difference in processing ORCs versus SRCs, as might have been demonstrated by effects on the embedded noun and the matrix verb, in addition to the difference we observed on the embedded verb. These results are consistent with our hypothesis that subject-verb integration is difficult when an inanimate NP must combine with an action verb; however, the results are inconsistent with a view that RC processing is made easier by altering the animacy configuration of the critical nouns (Gennari & MacDonald, 2008, 2009; Traxler et al., 2002, 2005).

The results of Experiment 1 differ from previous studies on RC processing that have found that the animacy of the embedded noun affects processing of the matrix verb (Gennari & MacDonald, 2008; Mak et al., 2002, 2006; Traxler et al., 2002, 2005). One possible reason for this discrepancy has to do with the choice of comparison condition. In our experiment, the two ORC conditions differed only at the embedded noun (e.g., *The sheriff that the cowboy injured…* versus *The sheriff that the pistol injured…*). In contrast, the two ORC conditions that previous studies have used differed in their head nouns, embedded nouns, and embedded verbs (e.g., *The pistol that the cowboy concealed…* versus *The cowboy that the pistol injured…*). Accordingly, differences at the matrix verb found by previous studies may have been influenced by differential spillover onto the embedded matrix verb from the preceding words. Overall, these differences in

stimulus materials may help explain the conflicting findings between the work presented here and the results of previous studies.

Furthermore, our findings are consistent with the notion that the integration of an inanimate subject NP with an action verb represents a form of enriched composition or metaphorical interpretation, which requires additional processing compared to the integration of an animate NP with a verb. For example, Pustejovsky (1995) has proposed that inanimate subject-verb pairs, such as *gun killed,* can only be properly understood via a process of coercion, where the noun is type-shifted from an object to an event. Several previous studies have demonstrated a processing cost associated with complement coercion, where the meaning of an expression is coerced from an object to an event (e.g., McElree et al., 2001; Traxler et al., 2002), as in *began the book* being interpreted as *began reading the book*. The current experiment is the first to demonstrate such a coercion cost for subject-verb integration.

Experiment 2

Experiment 1 demonstrated a local cost associated with integrating an inanimate subject with a verb, which was independent of the broader cost associated with processing an ORC as compared to a matched SRC. This demonstration of a local cost for integrating an inanimate noun with a verb raises the question of why such an effect was not observed in the SRC sentences on which the stimuli for Experiment 1 were based (Traxler et al. 2005, Experiment 3).

A possible explanation of these differing results is that for the sentences used in Experiment 1 the inanimate subject NP and the verb that had to be integrated appeared together in the same clause, whereas in Traxler et al.'s (2005) SRCs, the inanimate NP was the head which was modified through its integration with a verb that only appeared overtly in a different

clause. On several accounts of human language comprehension, the relations between different parts of a sentence are processed to varying degrees, with the depth of processing depending greatly on the structure of the sentence (e.g., Ferreira et al., 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). Direct evidence that information in a relative clause is processed less deeply in relation to the head than information in a main clause comes from Baker and Wagner (1987), who showed that false information is less likely to be detected by readers when the critical NP and verb phrase are presented in two different clauses, as in (6a), compared to when they appear in the same clause, as in (6b).

6a. The liver, which is an organ found only in humans, is often damaged by heavy drinking.

6b. The liver, which is often damaged by heavy drinking, is an organ found only in humans.

This work suggests that noun-verb pairs are not integrated as fully when they are separated by a clause boundary as when they appear together overtly in the same clause. This finding is particularly relevant to the current study, as it raises the possibility that a subject-verb pair such as *pistol injured* may be processed in very different ways, depending on whether the noun and verb appear in the same clause or in different clauses.

Accordingly, Experiment 2 explores whether the magnitude of the animacy effect depends on the syntactic structure of the sentence by examining the processing of subject-verb relations between the head NP of an SRC and the embedded verb. We predicted that the difficulty associated with integrating an inanimate subject and verb would be reduced when these constituents appeared in two separate clauses, compared to when they were in the same clause. This hypothesis was driven in part by Traxler et al.'s (2002, 2005) finding that there was no

difference in processing times for SRCs with an animate versus an inanimate head NP (i.e., no difference between 2c and 2d). However, based on the results of our Experiment 1, one might expect greater difficulty for (2d; *pistol injured*) compared to (2c; *cowboy concealed*). Finding no difference between these two sentences might suggest that the relations between the semantic properties of a subject and verb have reduced relevance when the verb is part of an embedded clause.

Method

Participants. Thirty-two students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials, design, and procedure. Each participant was presented with 40 experimental sentences and 84 filler sentences. The 40 experimental sentences were adapted from Traxler et al. (2005, Experiment 3). The SRCs from Traxler et al.'s experiment comprised two of our conditions (7a & 7c). Our other two conditions were created by dropping the complementizer of the SRCs and rewriting the end of the sentence such that the embedded verb was now the main verb of the sentence (7b & 7d). These changes allowed us to fully cross animacy (i.e., animate versus inanimate head NP) with syntax (i.e., SRC versus simple sentence; see Appendix B for full set of stimuli).

7a. The cowboy that concealed the pistol was known to be unreliable. (Animate-SRC)

7b. The cowboy concealed the pistol last night in the saloon. (Animate-Simple)

7c. The pistol that injured the cowboy was known to be unreliable. (Inanimate-SRC)

7d. The pistol injured the cowboy last night in the saloon. (Inanimate-Simple)

Fifteen participants who did not participate in the eye-tracking experiment rated these sentences for plausibility. As in Experiment 1, the task was to indicate how likely they believed the events described by the sentence were on a scale from 1 (highly unlikely) to 5 (highly likely). Each rater saw the sentences in a different random order. Mean plausibility ratings were 3.7 (Animate-SRC), 3.9 (Animate-Simple), 3.4 (Inanimate-SRC), and 3.6 (Inanimate-Simple). Analysis of these plausibility ratings revealed a significant main effect of syntax $F(1, 14) = 8.18$, $p < .05$, indicating higher ratings for simple sentences than SRCs. In addition, there was a significant main effect of animacy $F(1, 14) = 7.84$, $p < .05$, indicating higher ratings for sentences with animate versus inanimate NP1s. Critical to our hypothesis, however, there was no hint of an interaction between syntax and animacy, $F < 1$. Thus, any reading-time effects demonstrating reduced processing difficulty for inanimate subject NPs when they appear in an SRC compared to a simple sentence cannot be attributed to plausibility differences.

For the eye-tracking experiment, one version of each item was assigned to one of four lists such that no participant saw more than one version of each item. All other aspects of the design and procedure were identical to Experiment 1.

Results

As in Experiment 1, we report results for gaze duration, regression-path duration, total time, and comprehension-question accuracy. Reading times are presented in Table 3. In our analyses, we focused on the verb as our target region (i.e., main verb for simple sentences, embedded verb for SRCs), as this was the word where processing difficulty emerged for inanimate subjects in Experiment 1. The design of Experiment 2 allowed us to test for the presence of an interaction at this target region to determine whether the animacy effect depends on the syntactic structure of the sentence. For this analysis, a contingent-expansion technique

(Rayner & Duffy, 1986) was implemented for the SRC conditions, such that for trials where the target word was skipped but the complementizer was fixated, processing time on the complementizer was used in place of the target word.[3]

Table 3
Eye-tracking results of Experiment 2.

Region of Interest	Condition	Measure (in milliseconds)		
		Gaze	Regression-Path	Total Time
Determiner 1	Animate SRC	193		217
	Animate Simple	201		247
	Inanimate SRC	195		221
	Inanimate Simple	196		226
Noun 1	Animate SRC	272	295	551
	Animate Simple	250	274	526
	Inanimate SRC	258	300	534
	Inanimate Simple	256	304	630
Complementizer	Animate SRC	247	315	446
	Inanimate SRC	252	293	443
Verb	Animate SRC	269	343	547
	Animate Simple	287	379	640
	Inanimate SRC	256	322	571
	Inanimate Simple	312	415	734
Determiner 2	Animate SRC	214	259	318
	Animate Simple	224	301	314
	Inanimate SRC	223	267	327
	Inanimate Simple	225	296	332
Noun 2	Animate SRC	232	311	389
	Animate Simple	240	353	381
	Inanimate SRC	259	343	439
	Inanimate Simple	255	328	422

[3] There was no difference between animacy conditions in percentage of trials that went into the contingent expansion: animate head NP: 13%, inanimate head NP: 14%, $F_1(1, 31) < 1$; $F_2(1, 39) < 1$.

Verb. Analysis of gaze durations showed no main effect of animacy at the verb [$F_1(1, 31) = 1.12$, $MSE = 1831$, $p > .25$; $F_2(1, 39) = 1.14$, $MSE = 5028$, $p > .25$]. There was a main effect of syntax, such that simple sentences were read more slowly than SRCs [$F_1(1, 31) = 13.64$, $MSE = 3441$, $p < .01$; $F_2(1, 39) = 20.07$, $MSE = 3254$, $p < .001$]. Of primary importance, there was a significant interaction between syntax and animacy [$F_1(1, 31) = 6.33$, $MSE = 2867$, $p < .05$; $F_2(1, 39) = 9.08$, $MSE = 3821$, $p < .01$]. This interaction was probed further using two sets of contrasts: one holding syntax constant and one holding animacy constant. These analyses revealed that the Inanimate-Simple condition was more difficult than the Animate-Simple condition [$t_1(31) = 2.57$, $p < .05$; $t_2(39) = 2.20$, $p < .05$], but that there was no difference between the Inanimate-SRC condition and the Animate-SRC condition [$t_1(31) = 1.34$, $p > .19$; $t_2(39) = 1.16$, $p > .25$]. Furthermore, there was a large difference between the Inanimate-Simple and Inanimate-SRC conditions [$t_1(31) = 4.25$, $p < .001$; $t_2(39) = 4.86$, $p < .001$], but no difference between the Animate-Simple and Animate-SRC conditions [$t_1(31) = 1.08$, $p > .28$; $t_2(39) = .91$, $p > .36$].

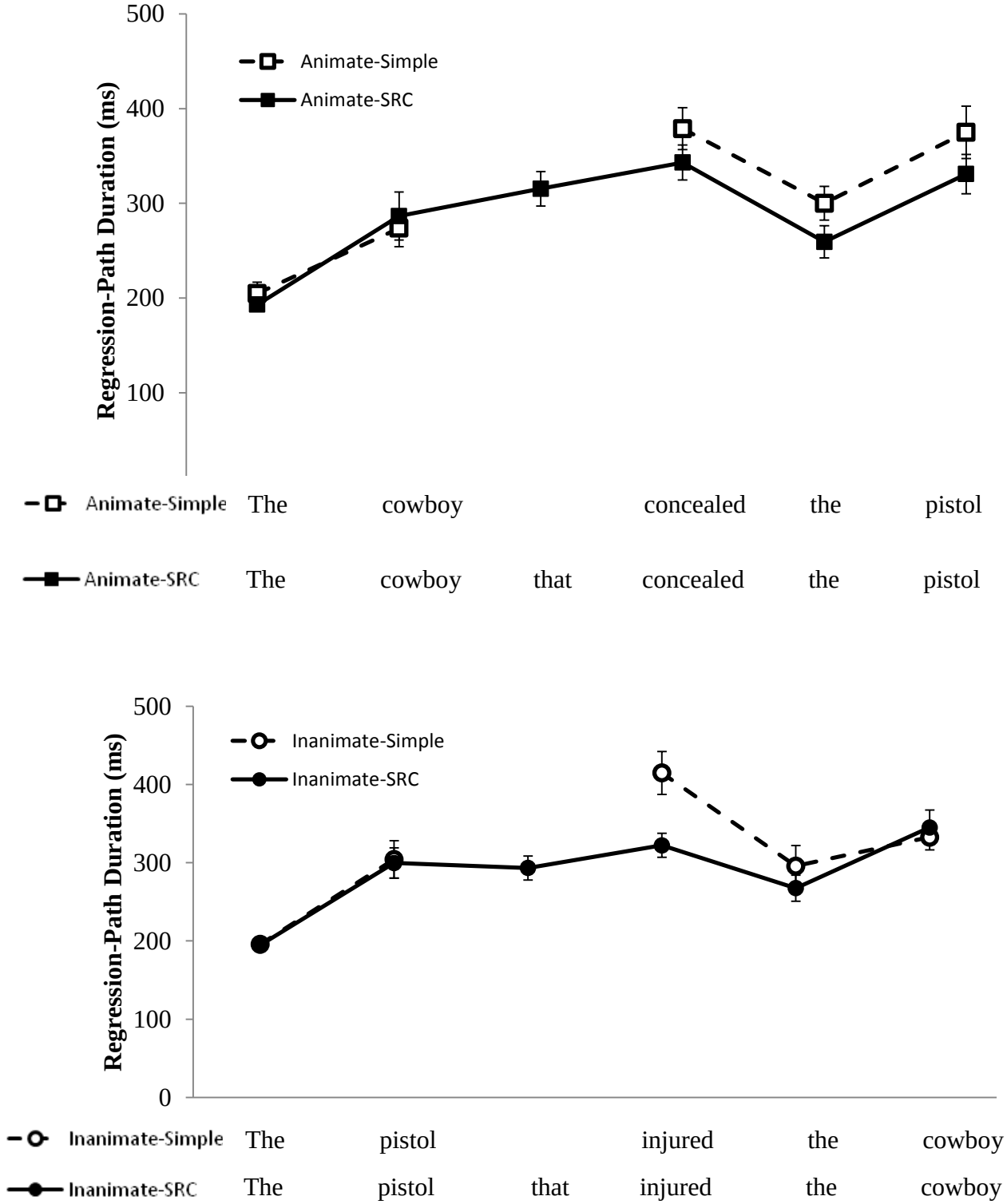
Analysis of regression-path durations at the verb revealed a pattern of effects identical to the findings obtained for gaze durations. Again, there was no main effect of animacy [$F_1(1, 31) < 1$; $F_2(1, 39) < 1$], but there was a main effect of syntax with simple sentences overall causing more difficulty than SRCs [$F_1(1, 31) = 10.00$, $MSE = 12362$, $p < .01$; $F_2(1, 39) = 12.41$, $MSE = 12474$, $p < .01$]. This main effect was qualified by the significant interaction between syntax and animacy [$F_1(1, 31) = 5.97$, $MSE = 5311$, $p < .05$; $F_2(1, 39) = 5.35$, $MSE = 12528$, $p < .05$]. Follow-up contrasts revealed greater difficulty with the Inanimate-Simple condition than the Animate-Simple condition [$t_1(31) = 2.04$, $p = .05$; $t_2(39) = 1.92$, $p < .07$], but no difference

between the Inanimate-SRC condition and the Animate-SRC condition [$t_1(31) = 1.54$, $p > .13$; $t_2(39) = 1.45$, $p > .15$]. In addition, there was a large difference between the Inanimate-Simple and Inanimate-SRC conditions [$t_1(31) = 4.11$, $p < .001$; $t_2(39) = 4.02$, $p < .001$], but no difference between the Animate-Simple and Animate-SRC conditions [$t_1(31) = 1.27$, $p > .20$; $t_2(39) = 0.87$, $p > .38$]. This pattern of effects is depicted graphically in Figure 2.

Finally, total times on the verb showed a significant main effect of syntax [$F_1(1, 31) = 32.13$, $MSE = 17302$, $p < .001$; $F_2(1, 39) = 24.66$, $MSE = 24769$, $p < .001$] and a main effect of animacy that was significant in the subjects analysis and marginal in the item analysis [$F_1(1, 31) = 5.33$, $MSE = 18200$, $p < .05$; $F_2(1, 39) = 3.23$, $MSE = 44388$, $p < .09$]. Also, there was a marginally significant interaction between syntax and animacy [$F_1(1, 31) = 3.05$, $MSE = 15866$, $p < .10$; $F_2(1, 39) = 3.42$, $MSE = 30153$, $p < .08$]. In line with the pattern of results obtained for gaze duration and regression-path duration, the total time data showed longer reading times on the verb for the Inanimate-Simple condition compared to the Animate-Simple condition [$t_1(31) = 2.75$, $p < .05$; $t_2(39) = 2.17$, $p < .05$], but no difference between the Inanimate-SRC condition and the Animate-SRC condition [$t_1(31) = .50$, $p > .60$; $t_2(39) = .28$, $p > .75$]. In addition, there was a large difference between the Inanimate-Simple and Inanimate-SRC conditions [$t_1(31) = 5.19$, $p < .001$; $t_2(39) = 4.19$, $p < .001$], which replicated the gaze duration and regression-path duration findings. Unlike these other two measures, however, the total time data also showed longer reading times for the Animate-Simple condition compared to the Animate-SRC condition [$t_1(31) = 2.95$, $p < .01$; $t_2(39) = 2.28$, $p < .05$].

Figure 2

Mean regression-path durations for the four conditions in Experiment 2. Error bars represent the standard error of the mean.



Additional reading-time effects. Gaze duration and regression-path duration on N1 showed no effects; however, analysis of the total time data on this word revealed an interaction between syntax and animacy that was significant in the item analysis and marginally significant in the subject analysis [$F_1(1, 31) = 3.24$, $MSE = 35308$, $p < .09$; $F_2(1, 39) = 6.10$, $MSE = 27698$, $p < .02$]. Follow-up contrasts showed longer total reading times on N1 for the Inanimate-Simple condition compared to the Animate-Simple condition [$t_1(31) = 2.29$, $p < .05$; $t_2(39) = 2.57$, $p < .05$], but no difference between the Inanimate-SRC condition and the Animate-SRC condition [$t_1(31) = .51$, $p > .60$; $t_2(39) = .39$, $p > .65$]. There were also marginally longer reading times on N1 for the contrast comparing the Inanimate-Simple condition to the Inanimate-SRC condition [$t_1(31) = 1.93$, $p < .07$; $t_2(39) = 1.87$, $p < .07$], but no hint of a difference between the Animate-Simple condition and the Animate-SRC condition [$t_1(31) = .68$, $p > .50$; $t_2(39) = 1.03$, $p > .30$]. The inflated total times on N1 in the Inanimate-Simple condition reflect readers' tendency to go back and reread earlier parts of the sentence after encountering difficulty at the verb. As such, these effects are in line with the pattern of results found at the verb in further demonstrating the difficulty associated with the Inanimate-Simple condition relative to the other conditions.

At the determiner following the verb, we observed a main effect of syntax in regression-path duration, such that there were significantly longer reading times for simple sentences compared to SRCs, regardless of animacy [$F_1(1, 31) = 4.20$, $MSE = 8870$, $p < .05$; $F_2(1, 39) = 6.75$, $MSE = 13682$, $p < .05$]. This finding may reflect general facilitation with processing an object NP when it is embedded in an RC compared to when it is in the same clause as the subject NP. On the other hand, the overall high skipping rates of this word (i.e., over 50% for all conditions) combined with the fact that this effect did not emerge on N2 make it difficult to interpret this effect on the article.

We did, however, observe significant main effects of animacy on N2, such that there was greater difficulty for sentences that had an inanimate sentence subject compared to sentences that had an animate sentence subject, regardless of syntax. This effect was significant in gaze duration [$F_1(1, 31) = 10.40$, $MSE = 1330$, $p < .005$; $F_2(1, 39) = 5.26$, $MSE = 3411$, $p < .05$] and in total time (significant in the subject analysis, marginal in the item analysis) [$F_1(1, 31) = 7.70$, $MSE = 8620$, $p < .01$; $F_2(1, 39) = 2.91$, $MSE = 21025$, $p < .10$]. Together with the findings obtained on the verb, these results suggest that the difficulty associated with the Inanimate-Simple condition begins early and extends to N2, whereas difficulty with the Inanimate-SRC condition does not emerge until after the verb.

There were no additional significant main effects or interactions.

Comprehension-question accuracy. Analysis of comprehension-question accuracies revealed a main effect of syntax, such that responses following simple sentences (96%) were significantly more correct than responses following SRCs (89%), $F_1(1, 31) = 16.63$, $MSE = 78$, $p < .001$; $F_2(1, 39) = 8.24$, $MSE = 216$, $p < .01$. There was no main effect of animacy, $F_1(1, 31) = 1.10$, $MSE = 38$, $p > .30$; $F_2(1, 39) < 1$, nor was there a syntax by animacy interaction, $F_1(1, 31) < 1$; $F_2(1, 39) < 1$.

Discussion

Experiment 2 replicated the finding from Experiment 1 that there is greater processing difficulty for inanimate compared to animate subject-verb pairs when the two words appeared together in the same clause. Whereas Experiment 1 had demonstrated this greater difficulty when the noun and verb both appeared in the embedded relative clause, Experiment 2 showed that this pattern is also observed when the noun and verb both appear in the main clause. Crucially, Experiment 2 further demonstrated that this processing difficulty was significantly

reduced when integration occurred across the boundary created by an SRC. This finding is consistent with the notion that the depth at which the words of a sentence are processed depends critically on the structure of the sentence.

General Discussion

Together, the two experiments reported in this paper demonstrate that the difficulty of integrating an inanimate subject with a verb depends on the syntactic structure of the sentence. Experiment 1 showed that subject-verb integration was difficult for inanimate subjects, compared to animate subjects, when the two constituents appeared together in the same clause. This difficulty emerged entirely at the verb, indicating that the animacy manipulation had no effect on processing times for any other part of the sentence. Experiment 2 showed that inanimate subject-verb integration was just as easy as animate subject-verb integration when the subject and verb appeared in two different clauses.

Our comparison of ORCs versus SRCs in Experiment 1 demonstrated that the processing difficulty occurs over a broad region of the sentence, encompassing the RC as well as the matrix verb. This finding is consistent with a large literature showing that the difficulty associated with processing an ORC is not confined to a single word (e.g., Ford, 1983; Gordon et al., 2001, 2004, 2006; Holmes & O'Regan, 1981; Johnson et al., 2011; King & Just, 1991; Traxler et al., 2002, 2005). In contrast, our comparison of ORCs with an animate versus an inanimate embedded NP showed that the animacy manipulation influenced reading times only at the embedded verb. Accordingly, these results provide no evidence that NP animacy influences RC processing per se. Instead, the difficulty associated with integrating an inanimate subject with a verb seems to be a localized effect.

A variety of linguistic and psycholinguistic accounts have previously proposed that integration of an inanimate subject NP with an action verb is difficult (Cruse, 1973; Dowty, 1991; Fillmore, 1968; Pustejovsky, 1995; Wolff et al., 2009, 2010). Depending on the nature of the particular subject-verb pair, this difficulty may stem from needing to access a metaphorical or metonymic sense of the noun (Frisson & Pickering, 1999; Gibbs, 1990), coercing the noun from an object to an event (Pustejovsky, 1995), or perceiving a mismatch between the semantic properties of the noun and the thematic properties specified by the verb (Dowty, 1991). The inanimate noun-verb pairs used in the current experiments were taken directly from previous research (Traxler et al., 2005; Experiment 3) so as to facilitate comparison of current results to those obtained previously. The heterogeneity of those inanimate noun-verb pairs in that research makes it difficult to identify the exact source or sources of the local processing difficulty in inanimate subject-verb integration.

Critically, the difficulty associated with integrating an inanimate subject NP with an action verb depended on syntactic structure, with the effect disappearing when the two constituents were in different clauses. This finding is in line with several theoretical accounts suggesting that the depth of sentence processing depends to a large extent on the structure of the sentence (e.g., Ferreira et al., 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). Specifically, work by Ferreira and colleagues (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, 2003; Ferreira, Christianson, & Hollingworth, 2001; see Ferreira & Patson, 2007 for a review) has demonstrated that participants who are presented with garden-path sentences or passive sentences that contain noncanonical agent-patient roles frequently misinterpret the meaning of the sentence. Similarly, Sanford and colleagues (Sanford, Sanford, Filik, & Molle, 2005; Sturt, Sanford, Stewart, & Dawydiak, 2004) have used a change-detection paradigm to

demonstrate that readers are more likely to notice that a target word has changed from one presentation of the text to the next if the word is linguistically focused by the sentence structure or is highlighted by a prior discourse context. Although this previous work provides compelling evidence that linguistic representations are often inaccurate or incomplete, the measures used combine the influences of both online linguistic processing and offline memory-based retrieval of the linguistic information. In contrast, the current work shows that the online processing time associated with integrating an inanimate subject-verb combination is reduced when the two constituents appear in separate clauses, showing that the process of interpretation depends critically on the structure of the sentence.

There is previous empirical support for the perspective that sentence structure can have a powerful impact on how linguistic representations are processed. As discussed above, Baker and Wagner (1987) demonstrated that readers are less likely to detect false information embedded in a sentence when the information appears as part of a subordinate clause, rather than as part of the main clause (see also Bredart & Modolo, 1988). Although the combination of an inanimate subject with an action verb does not constitute false information per se, our findings extend Baker and Wagner's results in demonstrating an online disruption in processing that is reduced by structural separation.

Focusing on sentence structure as it relates to the current experiments, it is important to note that the purpose of an RC is either to restrict the identity of the head noun or to modify its meaning. In other words, the RC is a modifying clause—an adjunct—and it has been argued that adjuncts do not depend heavily on the specifics of the head they modify (e.g., Schütze & Gibson, 1999). From this perspective, then, the semantic properties of a subject have a stronger influence on subject-verb integration when that subject NP is an argument of the verb, compared to when

the verb is part of an adjunct phrase. This finding can be explained by acknowledging that an RC typically conveys information that is presupposed, or given by the previous discourse context (Fox & Thompson, 1990; Gordon & Hendrick, 2005). Under this view, the RC grounds the head NP in information that is presumed to already be familiar to the comprehender , while less familiar information is presented in the main clause. In the case of subject-extracted RCs, such as the ones used in Experiment 2, NP1 serves as the subject of both the embedded verb and the main-clause verb, thus introducing two subject-verb relationships. Because the language comprehension system is limited, attentional resources must be allocated efficiently. For this reason, we believe that language processing focuses attention on the relationship between the head noun and the main verb of the sentence at the expense of the relationship between the head noun and the RC verb because such expressions typically convey presumed or contextual information.

In sum, this work demonstrates that there is a processing cost associated with integrating an inanimate subject with an action verb, but that this cost does not contribute to the higher-level syntactic difficulty associated with processing an ORC. Importantly, the magnitude of this processing difficulty depends on the structure of the sentence—it is larger when the inanimate noun is an argument of the action verb compared to when the action verb appears as part of an relative clause that identifies or modifies the meaning of the inanimate noun. We believe that this occurs because the depth at which people process relations between parts of a sentence is determined by its structure.

Transition to Chapter 3

In Lowder and Gordon (2012), we demonstrated that readers experience greater difficulty integrating a subject-verb pair when the subject is inanimate than when it is animate. As we noted, there are a variety of accounts that could in principle explain the source of this difficulty; however, the inanimate subject-verb pairs we used (adapted from Traxler et al., 2005) represent a heterogeneous set of materials, making it impossible to identify a single source of difficulty (see Appendices 1 and 2). To illustrate this problem, consider the sentences below.

The tornado killed Mary.	Force of nature
The machinery killed Mary.	Electric device
The stone killed Mary.	Projectile
The axe killed Mary.	Instrument

Wolff et al. (2010) have proposed that the difficulty associated with interpreting a causal construction involving an inanimate subject depends on the inanimate entity's inherent ability to generate its own energy. Under this account, an action verb like *kill* describes an event in which there is a causal relationship between the verb's two arguments (i.e., X killed Y). Critically, Wolff et al. propose that an inanimate entity's ability to create force is a major factor that determines how natural it will sound in subject position of a causal construction. As a result, inanimate entities can be conceptualized as lying somewhere on a *continuum of force creation*. On one end of this continuum are natural forces, which are fully capable of creating their own energy, even though they lack intention. On the other end of this spectrum are instruments, which derive all of their energy from an animate agent, and therefore often sound unnatural when combined with an action verb. Falling in the middle of this continuum are other types of inanimate entities such as electric devices, which do not create their own energy but transform energy from one form to another, and projectiles, which might appear as though they create their own force even though they acquire energy from an external source. Preliminary evidence

supporting this view comes from Wolff et al. (2009), who showed that English, Korean, and Mandarin speakers all rated sentences as significantly less acceptable when the sentence subject was an inanimate entity that was "low" in energy generation, compared to one that was "high" in energy generation.

Thus, inanimate nouns that represent instruments, tools, or weapons may be particularly difficult to integrate with an action verb compared to other classes of inanimate nouns. One plausible explanation for this is that constructions such as these may require the reader to engage in a process of figurative interpretation. In the sentence *The axe killed Mary*, for example, the subject NP *axe* is incapable of performing the action *kill* on its own. Thus, one may infer here that the weapon is being used as a referential expression to stand for the unnamed animate agent (e.g., *the one who wielded the axe*). This suggests a type of *metonymic* construction, where some salient characteristic of an entity refers to the entity as a whole. To the extent that the combination of an inanimate subject NP with an action verb represents a figurative expression, psycholinguistic theories conflict on the issue of whether literal and figurative meanings are processed differently. Whereas some models propose that a literal interpretation must be accessed before a figurative interpretation (e.g., Grice, 1975; Searle, 1979), others propose that neither the literal nor the figurative interpretation necessarily takes priority, but rather that the reader makes rapid use of the sentence context to immediately choose the intended meaning of the figurative expression (e.g., Glucksberg, 1991, 2003). Although a great deal of work has been devoted to better understanding the processing of figurative language in general, very little work has examined the processing of metonymy specifically. One prominent exception is Frisson and Pickering (1999), who measured eye movements while participants read sentences containing place-for-institution metonymies (e.g., *The bright boy was rejected by the college*) and place-for-

event metonymies (e.g., *A lot of Americans protested during Vietnam*). In both cases, Frisson and Pickering showed that processing the figurative sense of these familiar metonyms was just as easy as processing the same words when they were used in their literal sense.

Whereas Frisson and Pickering (1999) investigated the processing of place-for-institution and place-for-event metonyms, expressions such as *axe killed* and *pistol injured* are closer in form to what Lakoff and Johnson (1980) termed object-used-for-user metonyms (e.g., *The gun he hired wanted fifty grand*). The processing of these types of metonyms has been investigated by Gibbs (1990), who showed greater whole-sentence reading times when the sentence subject was an object-used-for-user metonym (e.g., *scalpel* to refer to *surgeon*), compared to both a literal condition (e.g., *doctor*) and a metaphorical condition (e.g., *butcher*). This work suggests that the integration of an inanimate subject with a verb may in some cases require the reader to adopt a figurative interpretation, which can impose a processing cost, though the whole-sentence reading time method did not allow this cost to be localized precisely.

The object-used-for-user metonyms studied by Gibbs (1990) were constructed so that the metonym referred to a person (e.g., *The scalpel was sued for malpractice*). In contrast, constructions like *The axe killed Mary* can be understood either by inferring that the instrument represents a person (e.g., *axe* to refer to *executioner*), or by inferring that the instrument represents an event (e.g., *someone's swinging of the axe killed Mary*). This perspective has also been discussed by Pustejovsky (1995) in his comparison of the two sentences presented in (1) below. Here, the verb *kill* specifies an action, and so it selects for an animate NP as its subject. This requirement is satisfied in (1a), but there is a semantic mismatch in (1b) that must be resolved. Specifically, Pustejovsky proposes that the inanimate subject in (1b) represents a type of metonymic construction that requires additional processing in order for it to make sense, and

calls the mechanism through which this deeper interpretation occurs *coercion*. That is, Pustejovsky proposes that the inanimate entity in (1b) makes sense as the subject of the sentence because it is coerced from an object (e.g., *the gun*) into an event involving an animate agent (e.g., *someone's shooting of the gun*).

1a. *John killed Mary.*
1b. *The gun killed Mary.*

Evidence that coercion incurs a processing cost has been found for NPs that syntactically appear as direct objects and which refer to entities (e.g., the book) when they follow verbs that require an event complement (e.g., began) as compared to those that take a direct object (e.g., write; McElree, Traxler, Pickering, Seely, & Jackendoff, 2001; Traxler, Pickering, & McElree, 2002). However, psycholinguistic evidence of coercion has not previously been reported for subject NPs that do not meet animacy specifications of verbs.

These various perspectives suggesting that some combinations of inanimate subject-verb pairs may require a figurative interpretation led me to become interested in the processing of metonymy and other types of figurative language. In addition, our results showing that the difficulty of integrating an inanimate subject with an action verb depends on sentence structure suggests that the processing of other types of complex semantic expressions, such as figurative language, may also depend on the structure of the sentence in which the critical constituents appear. In Lowder and Gordon (2013), we examine the effects of sentence structure on the processing of metonymy, finding that the relative ease or difficulty of processing this form of semantic expression depends critically on whether the metonym appears as an argument of the main verb or whether it appears as part of an adjunct phrase.

CHAPTER 3: Lowder and Gordon (2013)[4]

In everyday language comprehension we frequently encounter words that have multiple related meanings. For example, the word *college* can be used to refer to the physical space occupied by an institution of higher education, as in *Peter decided to leave the bike path and cut through the college*, or it can refer to the administration or other governing board of the institution, as in *Peter decided to petition the college to install more bike racks*. This latter example illustrates *metonymy*, a common type of figurative language in which some entity (e.g., *the administration of a university*) is referred to by some salient characteristic of that entity (e.g., *college*). Specifically, *petition the college* constitutes a place-for-institution metonym, where *college* does not refer to the literal, physical place, but rather to the larger institution associated with that place (Lakoff & Johnson, 1980). Other types of metonymy have also been documented. For example, the sentence *The ham sandwich is sitting at table 20* contains an object-used-for-user metonym, where *ham sandwich* does not refer to the literal sandwich, but rather to the customer who ordered the ham sandwich (Nunberg, 1978).

The manner in which metonymic expressions are understood factors into a general debate in the psycholinguistic literature over how we process figurative language. At a broad level, accounts of figurative-language processing differ in their predictions regarding the time course required to access a word's literal meaning compared to its figurative meaning. Psycholinguists

have characterized the *standard pragmatic model* (Grice, 1975; Searle, 1979) as an *indirect-access model* of figurative-language processing in which the literal meaning of a figurative expression is always accessed before a figurative interpretation is computed. If there is a mismatch between the literal interpretation and the context of the sentence, the literal meaning is rejected and a figurative interpretation is adopted instead. Although this model received some early empirical support (e.g., Clark & Lucy, 1975; Janus & Bever, 1985), the strict "literal-first" account has been challenged by demonstrations that when there is sufficient context readers can access figurative interpretations just as quickly as they can access literal interpretations (e.g., Gerrig & Healy, 1983; Inhoff, Lima, & Carroll, 1984; Ortony, Schallert, Reynolds, & Antos, 1978; Shinjo & Myers, 1987), and by demonstrations that certain figurative interpretations are automatically activated, even when an appropriate literal interpretation is available (Gildea & Glucksberg, 1983; Glucksberg, Gildea, & Bookin, 1982; Keysar, 1989). These findings have been taken as evidence for a *direct-access model* (Gibbs, 1994; Gibbs & Gerrig, 1989; Glucksberg, 1991, 2003) according to which neither a literal nor a figurative interpretation takes priority, but where contextual and lexical information interact immediately, allowing rapid selection of the intended meaning of a word. With increasing evidence that familiar figurative expressions are not necessarily more difficult to process than literal expressions (for reviews, see Glucksberg, 2001, 2003), researchers have shifted from the indirect-access model and toward the direct-access model.

Models of figurative-language processing have been based primarily on the comprehension of metaphor, with very few experimental studies examining the processing of metonymy. Some evidence suggests that familiar metonyms are no more difficult to process than literal expressions. Frisson and Pickering (1999) conducted two eye-tracking while reading

experiments that investigated the processing of familiar versus unfamiliar metonyms that appeared in either a literal or figurative context. In their Experiment 1, participants read sentences like those presented in (1). Here, *college* is a familiar place-for-institution metonym that can easily appear in either a literal context (1a) or a figurative context (1c). In contrast, *pyramid* has no familiar metonymic sense, and so it can easily appear in a literal context (1b), but it has no straightforward interpretation when it appears in a figurative context (1d).

(1a) *The photographer stepped inside the college after he had received an official invitation.*

(1b) *The photographer stepped inside the pyramid after he had received an official invitation.*

(1c) *That bright boy was rejected by the college after he had bribed some crooked officials.*

(1d) *That bright boy was rejected by the pyramid after he had bribed some crooked officials.*

Reading times on both the critical noun phrase (NP) and on the postnoun region revealed substantial processing difficulty when an unfamiliar metonym appeared in a figurative context (1d) compared to the other three conditions. In contrast, there was only weak evidence that the familiar metonym in a figurative context (1c) was more difficult than in a literal context (1a), and this effect emerged relatively late in the eye-tracking record. Frisson and Pickering's Experiment 2 found a similar pattern of results using familiar and non-familiar place-for-event metonyms (e.g., *Vietnam* can refer literally to the country or figuratively to the Vietnam war, whereas *Finland* has no familiar metonymic sense). Frisson and Pickering interpreted these

results as supporting an account of figurative-language processing in which readers do not initially distinguish between the literal and figurative meaning of a familiar metonym, but rather adopt a single, underspecified meaning and only later activate the intended sense. This account differs from earlier direct-access models (Gibbs, 1994; Gibbs & Gerrig, 1989; Glucksberg, 1991, 2003): whereas a direct-access account proposes that similar processing patterns for literal and figurative expressions are the result of the rapid influence of sentence context, the underspecification account instead argues that there is no difference between the processing of literal and figurative expressions because the reader does not make a strong initial commitment to either interpretation (for further discussion of the underspecification approach, see Frisson, 2009; Frisson & Pickering, 2001). Additional work has supported the idea that familiar metonymic interpretations are no more difficult to access than literal interpretations for both young and older adults (Humphrey, Kemper, & Radel, 2004) and in cases of producer-for-product metonyms (Frisson & Pickering, 2007; McElree, Frisson, & Pickering, 2006).

In contrast, other studies present evidence that the figurative meaning of a metonym is more difficult to access than its literal meaning. Gibbs (1990) presented participants with short narratives (e.g., a story about an incompetent surgeon) where the final sentence contained a referring expression that could be literal, metaphoric, or metonymic (e.g., *The doctor/butcher/scalpel was sued for malpractice*). He found that participants had the least difficulty establishing an antecedent in the literal condition compared to the two figurative conditions. However, participants were significantly slower in the metonymic condition compared to the metaphoric condition, leading Gibbs to conclude that metonymic referential expressions are more difficult to understand than other types of referential expressions (see also Onishi & Murphy, 1993). Frisson and Pickering (1999) noted that Gibbs did not make a

distinction between *sense selection* and *sense creation*. That is, the metonym condition in this study may have been more difficult than the others because readers are not used to referring to a doctor as a *scalpel*, and so they had to generate this novel sense of the word. This contrasts with a familiar metonym (e.g., *college*), where readers do not have to generate the meaning, but rather select it among several possible senses (see Clark & Gerrig, 1983; Gerrig, 1989). Additional research using neuroimaging (Rapp, Erb, Grodd, Bartels, & Markert, 2011), electrophysiology (Weiland, Bambini, & Schumacher, 2012), and speed-accuracy trade-off methodology (Ghio, Bott, Schumacher, & Bambini, 2012) has also shown clear differences in the processing of metonymic versus literal expressions.

In this paper, we propose that metonymic processing is influenced by sentence structure, which determines whether processing conforms to predictions derived from the indirect-access model or the direct-access model. This approach is consistent with a variety of psycholinguistic perspectives that have proposed that sentence structure guides the depth at which language comprehenders interpret referential expressions and relations between parts of a sentence (e.g., Baker & Wagner, 1987; Ferreira, Bailey, & Ferraro, 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). In particular, we test the hypothesis that metonyms are more difficult to process than literal expressions when they appear as an argument of a verb, but that this processing difficulty is reduced when the metonym appears as part of an adjunct phrase. This hypothesis was driven in part by our recent work (Lowder & Gordon, 2012) showing that changes in sentence structure affect the processing difficulty associated with integrating an inanimate sentence subject with an action verb (this work pertains to questions about how noun animacy influences complex-sentence processing: see Gordon & Lowder, 2012, Traxler, Morris, & Seely, 2002; Traxler, Williams, Blozis, & Morris, 2005; and questions about how information specified

by arguments and adjuncts is processed: Boland & Blodgett, 2006; Clifton, Speer, & Abney, 1991; Schutze & Gibson, 1999; Speer & Clifton, 1998). Lowder and Gordon recorded participants' eye movements while they read sentences like those in (2), where the sentence subject was either animate or inanimate and where an action verb appeared as either the main verb of the sentence or as part of a relative clause (i.e., an adjunct phrase). Lowder and Gordon found substantial processing difficulty at the verb for inanimate subjects versus animate subjects in a simple sentence context (2b versus 2a); however, there was no such animacy difference when the action verb was embedded in a relative clause (2d versus 2c).[5] This work demonstrated an important role for sentence structure in subject-verb integration. That is, the pairing of an inanimate subject with an action verb (e.g., *The pistol injured*) is difficult when this relationship is focused by virtue of being in the main clause of the sentence. In contrast, this difficulty is reduced when the integration takes place within a relative clause (e.g., *The pistol that injured*), presumably because the structure of the sentence signals to the reader that the information in this adjunct phrase is less important and thus requires less attention than the new information being asserted in the main clause of the sentence. This work also suggests that there may be other semantic characteristics of a sentence aside from animacy whose ease or difficulty of processing depends critically on sentence structure.

(2a) *The cowboy concealed the pistol last night in the saloon.*

(2b) *The pistol injured the cowboy last night in the saloon.*

[5] The greater processing difficulty for sentences like (2b) versus (2a) is unlikely to be due to temporary ambiguity at the verb between a main clause interpretation and a reduced-relative clause interpretation. First, the inanimate nouns used in Lowder and Gordon (2012) could not plausibly serve as the patient of an action verb (e.g., *The pistol injured by the cowboy…* is anomalous). More importantly, the greater difficulty observed in sentences like (2b) compared to (2d) was completely localized to the verb. If readers had entertained the possibility of a reduced-relative interpretation in (2b), then greater processing difficulty should have been observed on the subsequent, unambiguous NP (e.g., *the cowboy*) for (2b) compared to (2d).

(2c) *The cowboy that concealed the pistol was known to be unreliable.*

(2d) *The pistol that injured the cowboy was known to be unreliable.*

The notion that interactions between semantics and syntax of the sort reported by Lowder and Gordon (2012) might extend into research on figurative language is supported by the observation that several of the inanimate critical nouns used in that study could be interpreted metonymically (although in most cases the metonymic sense of the inanimate noun likely has to be created, rather than selected from an established metonymic sense). For example, an inanimate subject-verb pair such as *pistol injured* in (2b) resembles what Lakoff and Johnson (1980) called object-used-for-user-metonyms (e.g., *The gun he hired wanted fifty grand*), where in this case *pistol* could stand for *the man who was holding the pistol* or *someone's shooting of the pistol* (other examples of object-used-for-user metonyms from Lowder and Gordon include *the revolver shot* and *the wrench bruised*). In line with this perspective, Pustejovsky (1995) has proposed that sentences like (3b) require a metonymic interpretation. Whereas the animate entity *John* can easily be integrated with an action verb like *killed* in (3a), Pustejovsky proposes that we instead process (3b) by type-shifting the inanimate entity *the gun* from an object to an event involving an animate agent (e.g., *someone's shooting of the gun*). This semantic type-shifting process is called *coercion*.

(3a) *John killed Mary.*

(3b) *The gun killed Mary.*

We propose that inanimate subject-verb integration, coercion, metonymic processing, and other types of figurative language share a common source of processing difficulty in that they all require that a word be given a noncanonical semantic interpretation so that it makes sense in

relation to the meanings of other parts of the sentence. Sentence structure acts as one of several factors that can either emphasize or deemphasize the relevant semantic relation and therefore the need to make the noncanonical interpretation. In other words, a reader's limited attentional resources are guided to a large extent by sentence structure, such that certain elements and relations are processed deeply at the expense of other elements and relations. Specifically, when these sentential elements appear as arguments of a verb, their interpretation is critical to the overall coherence of the sentence, and so they are processed at a deep level, which leads to processing difficulty. In contrast, when these sentential elements are embedded in an adjunct phrase, they are seen as being less important to the meaning of the sentence, and so they are processed less deeply. This occurs because adjuncts are modifiers, and their interpretation does not depend strongly on the interpretation of the heads they modify (Schutze & Gibson, 1999). In addition, an adjunct phrase may signal to the reader that the information it contains is presupposed, and thus is not as important to focus on as the "new" information being asserted in the main clause of the sentence. We address several possible mechanisms that may explain differences in depth of processing in the General Discussion.

Lowder and Gordon's (2012) finding of greater processing difficulty for (2b) versus (2a) demonstrates that noncanonical arguments in the form of inanimate subjects cause processing difficulty when combined with an action verb. Critically, this cost is reduced when the subject-verb integration takes place in an adjunct phrase. The current paper extends these findings to figurative-language processing by demonstrating that the figurative interpretation of a metonym is more difficult to process than a literal expression when the critical word appears as the argument of the verb, but that this difference is reduced when the critical word is embedded in an adjunct phrase.

Experiment 1

Experiment 1 employed the metonyms and the basic design of Frisson and Pickering (1999) but modified their stimulus sentences so that the critical metonym was always an argument of the verb. As discussed above, Frisson and Pickering's Experiment 1 investigated the processing of place-for-institution metonyms as shown in (1; repeated here).

(1a) *The photographer stepped inside the college after he had received an official invitation.* (Literal-Familiar)

(1b) *The photographer stepped inside the pyramid after he had received an official invitation.* (Literal-Unfamiliar)

(1c) *That bright boy was rejected by the college after he had bribed some crooked officials.* (Metonymic-Familiar)

(1d) *That bright boy was rejected by the pyramid after he had bribed some crooked officials.* (Metonymic-Unfamiliar)

The critical NP in (1a) and (1c) is *the college*. In (1a), *college* is interpreted literally (i.e., the physical college campus), whereas in (1c), *college* is interpreted figuratively (i.e., the people who make up the admissions committee at the college). The critical NP in (1b) and (1d) is *the pyramid*. In (1b), *pyramid* is interpreted literally; however, there is no familiar metonymic sense associated with *pyramid*, and so (1d) is anomalous. We use the labels Literal and Metonymic to refer to the sentence context in which the critical word appears. We use the labels Familiar and Unfamiliar to refer to whether the target word has a familiar metonymic sense or not.

Whereas the indirect-access model predicts greater difficulty processing (1c) compared to (1a), the direct-access model predicts that there should be no difference. Frisson and Pickering (1999) tested these predictions in an eye-tracking while reading experiment using sentences like

in (1). Across several eye-tracking measures, they found robust context-by-metonym-familiarity interactions on the region immediately before the critical NP, on the critical NP itself, and on the region immediately following the critical NP. Follow-up analyses showed that the driving force behind these interactions was extreme processing difficulty associated with the Metonymic-Unfamiliar condition (e.g., *rejected by the pyramid*), which led Frisson and Pickering to conclude that whereas unfamiliar metonyms are difficult to process, familiar metonyms are processed very easily whether they appear in a literal or figurative context. Of particular interest, the greater difficulty for the Metonymic-Unfamiliar condition over the other three conditions emerged in first-pass reading of the critical NP, suggesting that early stages of lexical access are sensitive to metonymic processing. Whereas lexical access was difficult for a word that was used in an unfamiliar metonymic context compared to when it was used in its literal context (e.g., *rejected by the pyramid* versus *stepped inside the pyramid*), there was no difference when the critical word had a familiar metonymic sense (e.g., *rejected by the college* versus *stepped inside the college*). This outcome supports the direct-access model in showing that readers used the context of the sentence to rapidly determine which sense of a familiar metonym to select; because there is no familiar figurative sense associated with *pyramid*, a process of sense creation must take place. The results also support Frisson and Pickering's underspecification model, where the reader initially activates only an underspecified meaning of a familiar metonym and later selects the appropriate sense.

Notwithstanding this conclusion, Frisson and Pickering (1999) did obtain some evidence that Metonymic-Familiar (e.g., *rejected by the college*) was more difficult than Literal-Familiar (*stepped inside the college*). Specifically, they found that readers were more likely to regress to earlier regions of the sentence after having read the critical NP in the Metonymic-Familiar

compared to the Literal-Familiar. Also, there was evidence for greater total reading times for the Metonymic-Familiar condition than for the Literal-Familiar condition on both the critical NP as well as the region immediately following it. Frisson and Pickering acknowledge these differences, but note that these effects were relatively weak. Furthermore, Frisson and Pickering point out that the greater difficulty associated with the Metonymic-Unfamiliar condition emerged early in the eye-tracking record, whereas the smaller difference between the Metonymic-Familiar and Literal-Familiar conditions did not emerge until later processing measures. Thus, Frisson and Pickering claim that their results offer only weak support for the indirect-access model.

In Experiment 1 we tested the hypothesis that a clear processing difference between familiar metonyms used in their literal versus figurative contexts would emerge in a set of materials that more carefully controls the sentence position of the critical NP (see 4 for an example). Specifically, we modified Frisson and Pickering's (1999) materials in two important ways. First, we rewrote the verb phrase of each set of items such that the critical NP would always appear as the object of the verb. Although this was already the case in some of Frisson and Pickering's materials (e.g., *the famous drug smuggler provoked the court*; *the grateful old lady thanked the store*), it was more often the case that the critical NP appeared as part of an adjunct phrase (e.g., *the bright boy was rejected by the college*; *the guards got instructions from the headquarters*), or at least followed a preposition that intervened between the verb and the noun (e.g., *the young expert cooperated with the gallery*; *that blasphemous young woman had to answer to the convent*). This variability in sentence structure occurred not only within the figurative contexts, as in the above examples, but also in the literal contexts (compare, e.g., *those angry protestors surrounded the embassy* and *the cab driver dropped us off at the treasury*). Second, Frisson and Pickering used different sentence frames within a set of items to evoke the

literal versus figurative sense of the critical word (compare 1a and 1b to 1c and 1d). This was done to allow two items within a set to appear on the same experimental list (e.g., 1a and 1d were paired together). We take a similar approach to our design; however, we also constructed additional sentences to increase our total number of items.

(4a) *Sometime in August, the journalist photographed the college after he had received an official invitation.* (Literal-Familiar)

(4b) *Sometime in August, the journalist photographed the pyramid after he had received an official invitation.* (Literal-Unfamiliar)

(4c) *Sometime in August, the journalist offended the college after he had bribed some crooked officials.* (Metonymic-Familiar)

(4d) *Sometime in August, the journalist offended the pyramid after he had bribed some crooked officials.* (Metonymic-Unfamiliar)

As discussed above, Lowder and Gordon (2012) demonstrated that sentence structure moderates semantic integration, with processing difficulty emerging when a noncanonical argument is paired with an action verb. Similarly, we predicted that readers would experience difficulty processing both familiar and unfamiliar metonyms when the critical word appeared as an argument of the verb. Critically, because the metonym involves a noncanonical interpretation and is focused by virtue of its being an argument of the verb, this greater difficulty for metonyms used in a figurative versus a literal context should emerge early in the eye-tracking record and should not depend on familiarity of the metonym. Based on the results of Frisson and Pickering (1999), we also predicted that readers would experience greater difficulty processing unfamiliar metonyms compared to familiar metonyms, but we expected this difficulty to emerge relatively late in the eye-tracking record.

Method

Participants. Twenty-eight students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials. Each participant was presented with 32 experimental sentences and 92 filler sentences. The experimental sentences were adapted from Frisson and Pickering (1999, Experiment 1). Everything from the critical NP to the end of the sentence was identical to the materials used by Frisson and Pickering. Critically, we changed the verb phrases such that they always consisted of only one word, which would then take the critical NP as its object. This required us to change the sentence subject in some cases, but not in others. Finally, we began every sentence with a locative phrase. See (4) for an example.

Each set of items was yoked to another set of items that contained the same verbs and critical NPs but contained a different locative phrase and a different sentence subject (see 5). This was done to allow pairing of items across four lists, but to also maintain tight experimental control. Thus, in constructing our counterbalanced lists, (4a) and (5d) always appeared together, as did (4b) and (5c), and so on. See Appendix A for a full list of materials.

(5a) *Over the summer, the writer photographed the college after he had received an official invitation.* (Literal-Familiar)

(5b) *Over the summer, the writer photographed the pyramid after he had received an official invitation.* (Literal-Unfamiliar)

(5c) *Over the summer, the writer offended the college after he had bribed some crooked officials.* (Metonymic-Familiar)

(5d) *Over the summer, the writer offended the pyramid after he had bribed some crooked officials.* (Metonymic-Unfamiliar)

The critical nouns we used (e.g., *college* versus *pyramid*) came directly from Frisson and Pickering (1999), who had carefully balanced them for frequency and length. Likewise, we selected verbs for the literal and metonymic contexts that did not differ significantly in frequency, $t(30) = 1.17$, $p > .24$ (SUBTLEXus database, Brysbaert & New, 2009), and that were identical in length. Frisson and Pickering had demonstrated that there were no differences in average frequencies of the literal and figurative senses of the familiar metonyms.

Plausibility norming. To test for differences in plausibility among the four conditions, we presented the stimuli from Experiment 1 up to and including the critical noun (e.g., *Over the summer, the writer photographed the college.*) to 20 participants who did not participate in the eye-tracking experiment. There were four versions of each list that were counterbalanced into the same lists used for the eye-tracking experiment. Each list also contained filler sentences. Participants were instructed to indicate how likely they believed the events described by the sentence were on a scale from 1 (highly unlikely) to 7 (highly likely). Each participant saw the sentences in a different random order. The mean ratings for each condition were 5.5 (Literal-Familiar), 5.5 (Literal-Unfamiliar), 4.7 (Metonymic-Familiar), and 2.4 (Metonymic-Unfamiliar). All pairwise comparisons differed significantly from each other except for the two Literal conditions, all ts > 2.6, all ps < .05. This pattern of plausibility results is identical to the pattern obtained by Frisson and Pickering (1999). Although the Literal-Familiar and Metonymic-Familiar conditions were significantly different from one another, the magnitude of this difference was quite small, especially compared to the larger difference between the Metonymic-Familiar and Metonymic-Unfamiliar conditions (see also Footnote 6).

Predictability. A group of 16 participants, none of whom participated in any other aspect of the study, were presented with the stimuli from Experiment 1 up to and including the determiner before the critical noun (e.g., *Over the summer, the writer photographed the …*) and were instructed to complete each fragment. The fragments were presented in one of four possible orderings. Participants' responses were then compared with the actual experimental stimuli to assess how predictable the critical words were. The percentages of responses that matched the critical words were extremely low across all conditions: 0.4% (Literal-Familiar), 0.4% (Literal-Unfamiliar), 1.2% (Metonymic-Familiar), and 0% (Metonymic-Unfamiliar).

Procedure. Participants' eye movements were recorded with an EyeLink 1000 system (SR Research) at a sampling rate of 1000 Hz with a headrest used to minimize movement. At the start of each trial, a fixation point was presented near the left edge of the monitor, marking the location where the first word of the sentence would appear. When the participant fixated this point, the experimenter pressed a button that replaced the fixation point with the sentence. After reading the sentence, the participant pressed a key, which made the sentence disappear and a true-false comprehension question appear. Participants pressed one key to answer "true," and another key to answer "false." A comprehension question followed every sentence.

Each experimental session began with four filler sentences. After this warm-up block, the remaining 120 sentences were presented in a different random order for each participant.

Analysis. Data analysis focused on four standard eye-movement measures. *Gaze duration* is the sum of all initial fixations on a region; it begins when the region is first fixated and ends when gaze is directed away from the region, either to the left or right. *Right-bounded reading time* (also called *quasi-first pass time*) is similar to gaze duration, except it ends when gaze is directed away from the region to the right. This measure is not discussed as often as the

others reported here, but it has nevertheless been used in several eye-tracking while reading studies (e.g., Betancort, Carreiras, & Sturt, 2009; Gordon, Hendrick, Johnson, & Lee, 2006; Lee, Lee, & Gordon, 2007; Traxler et al., 2002). *Regression-path duration* (also called *go-past time*) is the sum of all fixations beginning with the initial fixation on a region and ending when the gaze is directed away from the region to the right. Thus, regression-path duration includes right-bounded reading time, but also includes any regressive fixations to earlier parts of the sentence. *Total time* is the sum of all fixations on a word or region. For our analyses of these measures, we excluded 0-ms times, which occur when a critical region is skipped during first pass (e.g., Frisson & Pickering, 1999; Pickering & Traxler, 1998, 2001). Throughout the paper, we use gaze duration to assess the earliest stages of processing, right-bounded reading time and regression-path duration to assess intermediate stages of processing, and total time to assess global processing difficulty.

We report reading times for three regions of interest. The *prenoun region* consisted of the subject of the sentence (bare noun only) and the main verb (e.g., *journalist photographed*/*journalist offended*). The *critical NP* consisted of the target word along with the determiner (e.g., *the college*/*the pyramid*). The *postnoun region* consisted of the three words following the critical NP in most cases (e.g., *after he had*). Note that these words are the same across the literal and metonymic conditions. In four of our item sets, only two words remained constant between conditions. Following Frisson and Pickering (1999), the postnoun region for those items consisted of only those two words. When two or more consecutive regions were skipped during first pass, the trial was excluded.

An automatic procedure in the Eyelink software combined fixations that were shorter than 80 ms and within one character of another fixation into one fixation. Additional fixations

shorter than 80 ms and longer than 1,000 ms were removed. For all reading-time measures, we set minimum cutoff values at 120 ms. Maximum cutoff values were set at 1,500 ms for gaze duration and 3,000 ms for all other measures (for similar approaches see, e.g., Frisson & McElree, 2008; Frisson & Pickering, 2007; McElree et al., 2006; Tooley, Traxler, & Swaab, 2009; Traxler, 2009; Traxler & Tooley, 2008). This procedure eliminated 1.6% of the data.

Results

Comprehension-question accuracy. Mean comprehension-question accuracies for each condition were as follows: Literal-Familiar (97%), Literal-Unfamiliar (95%), Metonymic-Familiar (94%), Metonymic-Unfamiliar (90%). Because these values were all extremely close to the upper limit of the distribution, the data were arcsine-transformed prior to calculation of inferential statistics (Cohen, Cohen, West, & Aiken, 2003; for a similar approach, see, e.g., Johnson, Lowder, & Gordon, 2011). The analysis revealed a main effect of context that was only significant in the subject analysis, $F_1(1, 27) = 8.60$, $MSE = .10$, $p < .01$; $F_2(1, 31) = 2.32$, $MSE = .30$, $p > .13$. Although this difference was unexpected, we do not attribute it to differences in the processing of literal versus figurative expressions. Rather, it is important to note that the comprehension questions following sentences in the literal condition were different from the questions following sentences in the metonymic condition due to the differences in sentence frames. Furthermore, the questions following sentences in the metonymic condition never probed the reader's interpretation of the critical word. For example, the question following (5c) and (5d) was, "True or False: The writer was of the highest morals." It thus seems possible that differences in the difficulty of the questions between the literal and figurative conditions are responsible for the slight differences in accuracy. However, because this effect did not approach significance in the item analysis and because accuracy was very high across all conditions, we do

not place much weight on this finding. The main effect of metonym familiarity and the interaction between context and familiarity were not significant.

Prenoun region. Mean reading times for the three regions of interest are displayed in Table 4. Reading times from all trials were included, regardless of whether the comprehension question was answered correctly. No statistically significant main effects or interactions were observed in the prenoun region for gaze duration, right-bounded reading time, or regression-path duration, demonstrating that processing difficulty for the four conditions did not differ prior to encountering the critical NP.

In contrast, the prenoun region showed a robust main effect of context for total time, such that there were longer reading times on the prenoun region for the metonymic contexts compared to the literal contexts, $F_1(1, 27) = 26.91$, $MSE = 20{,}276$, $p < .001$; $F_2(1, 31) = 19.52$, $MSE = 29{,}707$, $p < .001$. There was no main effect of metonym familiarity, $F_1(1, 27) = 1.94$, $MSE = 46{,}948$, $p > .15$; $F_2(1, 31) = 1.16$, $MSE = 62{,}835$, $p > .25$, nor was there any evidence of a context-by-familiarity interaction, $F_1(1, 27) < 1$; $F_2(1, 31) < 1$. This pattern suggests that readers experienced processing difficulty when they encountered a noun that had to be interpreted figuratively, causing them to go back and reread earlier parts of the sentence.

Critical NP. Measures assessing early and intermediate stages of processing on the critical NP showed that metonyms were more difficult to process than literal expressions, regardless of metonym familiarity. Analysis of gaze duration on the critical NP revealed a significant main effect of context, $F_1(1, 27) = 8.77$, $MSE = 3{,}526$, $p < .01$; $F_2(1, 31) = 5.91$, $MSE = 5{,}922$, $p < .05$, with longer reading times for the metonymic contexts compared to the literal contexts. There was no main effect of metonym familiarity, $F_1(1, 27) < 1$; $F_2(1, 31) < 1$, nor was

there a context-by-familiarity interaction, $F_1(1, 27) = 1.19$, $MSE = 3{,}906$, $p > .28$; $F_2(1, 31) = 1.13$, $MSE = 6{,}716$, $p > .29$.

Table 4
Results of Experiment 1.

Measure (in milliseconds)	Prenoun region	Critical NP	Postnoun region
Literal-Familiar	*journalist photographed*	*the college*	*after he had*
Literal-Unfamiliar	*journalist photographed*	*the pyramid*	*after he had*
Metonymic-Familiar	*journalist offended*	*the college*	*after he had*
Metonymic-Unfamiliar	*journalist offended*	*the pyramid*	*after he had*
Gaze duration			
Literal-Familiar	543	363	377
Literal-Unfamiliar	558	369	385
Metonymic-Familiar	546	409	400
Metonymic-Unfamiliar	517	390	389
Right-bounded reading time			
Literal-Familiar	596	459	435
Literal-Unfamiliar	641	444	416
Metonymic-Familiar	607	504	450
Metonymic-Unfamiliar	606	505	483
Regression-path duration			
Literal-Familiar	642	588	568
Literal-Unfamiliar	676	548	469
Metonymic-Familiar	649	636	547
Metonymic-Unfamiliar	654	661	613
Total time			
Literal-Familiar	1,086	709	632
Literal-Unfamiliar	1,119	702	661
Metonymic-Familiar	1,201	749	655
Metonymic-Unfamiliar	1,283	918	705

Note. NP = noun phrase.

The main effect of context was also significant in both right-bounded reading time, $F_1(1, 27) = 10.04$, $MSE = 7{,}934$, $p < .005$; $F_2(1, 31) = 5.40$, $MSE = 14{,}024$, $p < .05$, and in regression-path duration, $F_1(1, 27) = 5.80$, $MSE = 31{,}365$, $p < .05$; $F_2(1, 31) = 6.30$, $MSE = 27{,}093$, $p < .05$. These two measures showed no main effects of metonym familiarity and no context-by-familiarity interaction, all Fs < 1.2. Thus, analysis of gaze duration, right-bounded reading time, and regression-path duration at the critical NP all suggest greater processing difficulty when the critical NP appeared in a metonymic context compared to a literal context, and there was no evidence that familiar metonyms were easier to process than unfamiliar metonyms.[6]

In contrast, analysis of total time on the critical NP revealed a significant context-by-familiarity interaction, $F_1(1, 27) = 12.27$, $MSE = 17{,}169$, $p < .005$; $F_2(1, 31) = 7.78$, $MSE = 26{,}210$, $p < .01$. Follow-up analyses with planned comparisons showed that the Metonymic-Unfamiliar condition was more difficult than the Literal-Unfamiliar condition, $t_1(27) = 5.64$, $p < .001$; $t_2(31) = 5.31$, $p < .001$, but that there was no difference between the Metonymic-Familiar condition and the Literal-Familiar condition, $t_1(27) = 1.23$, $p > .20$; $t_2(31) = 1.19$, $p > .20$.

Postnoun region. No statistically significant main effects or interactions were observed for gaze duration in the postnoun region. Analysis of right-bounded reading time in the postnoun region revealed a significant main effect of context, $F_1(1, 27) = 7.84$, $MSE = 6{,}028$, $p < .01$; $F_2(1, 31) = 6.90$, $MSE = 9{,}479$, $p < .05$ and a marginally significant context-by-familiarity interaction, $F_1(1, 27) = 3.33$, $MSE = 5{,}847$, $p < .08$; $F_2(1, 31) = 3.89$, $MSE = 7{,}998$, $p < .06$. The context-by-familiarity interaction was fully significant for regression-path duration, $F_1(1, 27) = 8.23$, $MSE =$

[6] To determine whether the greater processing difficulty associated with familiar metonyms compared to literal expressions could be explained by plausibility differences between these two conditions, we correlated the difference in reading times between items in the Metonymic-Familiar and Literal-Familiar conditions with the difference in their plausibility ratings. This correlation was performed for all regions of interest on every eye-tracking measure that showed an effect of context. There was no indication that plausibility differences had any influence on reading times, all rs < .18, all ps > .32.

23,113, $p < .01$; $F_2(1, 31) = 6.71$, $MSE = 32{,}664$, $p < .05$. Planned comparisons showed that the Metonymic-Unfamiliar condition was more difficult than the Literal-Unfamiliar condition, $t_1(27) = 4.12$, $p < .001$; $t_2(31) = 3.51$, $p < .005$, but that there was no difference between the Metonymic-Familiar condition and the Literal-Familiar condition, $t_1(27) < 1$; $t_2(31) = < 1$. For total time on the postnoun region, there was a main effect of metonym familiarity that was significant only in the subjects analysis, $F_1(1, 27) = 4.44$, $MSE = 9{,}878$, $p < .05$; $F_2(1, 31) = 2.66$, $MSE = 19{,}544$, $p > .10$. There was no significant main effect of context, $F_1(1, 27) = 2.11$, $MSE = 14{,}464$, $p > .15$; $F_2(1, 31) = 1.99$, $MSE = 24{,}605$, $p > .15$, nor was there a context-by-familiarity interaction, $F_1(1, 27) < 1$; $F_2(1, 31) < 1$.

Discussion

The results of Experiment 1 show that both familiar and unfamiliar metonyms cause processing difficulty, but that the difficulty caused by unfamiliar metonyms is more prolonged than that for familiar metonyms. Measures reflecting early and intermediate stages of processing (gaze duration, right-bounded reading time, and regression-path duration) on the critical NP showed that figurative expressions were more difficult than literal expressions, regardless of the familiarity of the metonym. The greater overall difficulty for figurative expressions over literal expressions persisted in right-bounded reading time on the postnoun region, and total time on the prenoun region.

We also found evidence that the Metonymic-Unfamiliar condition (e.g., *offended the pyramid*) was more difficult than the Metonymic-Familiar condition (e.g., *offended the college*); however, this effect did not emerge until relatively late in the eye-tracking record (regression-path duration on the postnoun region and total time on the critical NP). This pattern contrasts with the results reported by Frisson and Pickering (1999), who demonstrated that greater

difficulty processing their Metonymic-Unfamiliar condition (e.g., *rejected by the pyramid*) compared to their Metonymic-Familiar condition (e.g., *rejected by the college*) emerged early (i.e., in gaze duration on the critical NP).

The overall pattern of the results of Experiment 1 is consistent with the indirect-access model of figurative-language processing. According to this model, the literal meaning of a figurative expression is always accessed before the figurative meaning, which results in early processing difficulty when a metonym is first encountered—even if the figurative meaning of the metonym is well-established. However, the model also predicts that readers should experience longer-lasting difficulty with an unfamiliar metonym compared to a familiar metonym (Frisson & Pickering, 1999). Presumably this occurs because whereas the figurative sense of a familiar metonym can be *selected* among its various possible meanings, the figurative sense of an unfamiliar metonym must be *created*, which requires additional processing time.

We propose that the discrepant findings between the current study and Frisson and Pickering (1999) can be explained by taking sentence structure into consideration. Whereas the critical NPs in our Experiment 1 always appeared as an argument of the main verb of the sentence, the critical NPs used by Frisson and Pickering varied in their syntactic role, sometimes occurring as an argument of the verb, but more often appearing as part of an adjunct phrase, which may have reduced the processing difficulty associated with the metonym. We believe that this occurs because the structure of our sentences focused the reader's attention on this noncanonical semantic relationship, leading to deeper interpretation compared to a sentence where the metonym and the verb, while related in the sentence, have greater separation within the structure of the sentence. This notion is consistent with Lowder and Gordon (2012), who showed that inanimate subject-verb integration is difficult when the subject is an argument of the

main verb of the sentence (e.g., *the pistol injured*), but that this difficulty is reduced when the verb is embedded in an adjunct phrase (e.g., *the pistol that injured*). This latter finding of Lowder and Gordon leads to the prediction that metonymic processing difficulty should be reduced when the metonym appears as part of an adjunct phrase compared to when it is an argument.

Experiment 2

Experiment 2 tested the hypothesis of Lowder and Gordon (2012) that sentence structure guides the depth to which readers interpret meaningful relations between parts of sentences by examining whether the processing difficulty found in Experiment 1 for familiar metonyms would be reduced when they appeared as part of an adjunct phrase compared to when they appeared as an argument of the verb. Specifically, Experiment 2 examined the processing of sentences like those presented in (6). A comparison of (6c) versus (6d) provides a test of the hypothesis that metonymic processing depends on sentence structure. Support for this hypothesis would help reconcile conflicting results on whether there is a processing cost associated with interpretation of metonyms (Frisson & Pickering, 1999, 2007; Ghio et al., 2012; Gibbs, 1990; Humphrey et al., 2004; McElree et al., 2006; Rapp et al., 2011; Weiland et al., 2012). In addition Experiment 2 tested whether interpreting familiar metonyms imposes a processing cost when compared to a different baseline. Whereas place-for-institution metonyms (e.g., *offended the college*) refer indirectly to people (e.g., *the individuals who make up the administration of the college*), these metonyms can be substituted with an NP that refers directly to a person or a group of people (e.g., *offended the leader*; see 6a and 6b). This comparison offers an additional test of models of figurative-language processing. Again, whereas the indirect-access model predicts that readers

will encounter difficulty with a metonymic expression compared to a literal expression, the direct-access model instead predicts that there should be no difference.

(6a) *Sometime in August, the journalist offended the leader after he had published that negative article.* (Person-Argument)

(6b) *Sometime in August, the journalist offended the honor of the leader after he had published that negative article.* (Person-Adjunct)

(6c) *Sometime in August, the journalist offended the college after he had bribed some crooked officials.* (Metonym-Argument)

(6d) *Sometime in August, the journalist offended the honor of the college after he had bribed some crooked officials.* (Metonym-Adjunct)

It should be noted that our manipulation of sentence structure also introduces changes in the semantic content of the sentences in the Argument conditions compared to the Adjunct conditions. That is, whereas all conditions contain a verb (e.g., *offended*) that indicates the need for an animate patient or an entity that can be interpreted as having animate qualities, the Adjunct conditions also contain an additional content word (e.g., *honor*) that may further cue the reader that the target word should be interpreted as an animate entity. We return to this issue in the Discussion.

Method

Participants. Forty-four students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials. Each participant was presented with 32 experimental sentences and 92 filler sentences. The experimental sentences were modified versions of the experimental sentences used in Experiment 1. See (6) for an example. The critical NPs for the metonymic condition were the same familiar metonyms as those used in Experiment 1 (e.g., *the college*). In addition to the metonymic condition, we introduced a condition that directly named a person (e.g., *the leader*). The critical NPs could appear as the object of the verb, as in Experiment 1, or as part of an adjunct phrase. The adjunct condition was constructed by selecting a new NP that could serve as the object of the verb and that could be attributed either to a person or to an institution via a prepositional phrase (e.g., *the honor of the leader* or *the honor of the college*). The initial locative phrase and sentence subject were the same as in Experiment 1. In most cases, the postnoun region of the sentence was the same as in Experiment 1, but modifications had to be made in some cases to keep the sentence coherent. See Appendix B for a full list of materials. The critical nouns used for the person condition (e.g., *leader*) versus the metonymic condition (e.g., *college*) did not differ in frequency, $t(30) < 1$ (SUBTLEXus database, Brysbaert & New, 2009) or length, $t(30) < 1$.

Plausibility norming. As in Experiment 1, we collected plausibility ratings for the items used in Experiment 2. Twenty participants who did not participate in any other portion of this study were presented with the critical sentences up to and including the critical noun. There were four versions of each list that matched the counterbalancing used for the eye-tracking experiment. Each list also contained filler sentences. Participants were instructed to indicate how likely they believed the events described by the sentence were on a scale from 1 (highly unlikely) to 7 (highly likely). Each participant saw the sentences in a different random order. The mean ratings for each condition were 5.4 (Person-Argument), 5.3 (Person-Adjunct), 5.3

(Metonym-Argument), and 5.3 (Metonym-Adjunct). There were no significant differences between any condition, all *t*s < 1.2, all *p*s > .25. Thus, any differences in reading times between sentences with people NPs versus metonyms and any influence of sentence structure on these reading times cannot be attributed to differences in plausibility.

Predictability. The stimuli from Experiment 2 were assessed for predictability of the critical noun just as described in Experiment 1. Sixteen participants provided sentence completions. As in Experiment 1, the percentages of responses that matched the critical words were extremely low across all conditions: 2.7% (Person-Argument), 1.6% (Person-Adjunct), 0.8% (Metonym-Argument), and 1.6% (Metonym-Adjunct).

Procedure. All aspects of the eye-tracking procedure were identical to Experiment 1.

Analysis. As in Experiment 1, data analysis of Experiment 2 focused on measures of gaze duration, right-bounded reading time, regression-path duration, and total time. We defined three regions of interest—the prenoun region, critical NP, and postnoun region—just as we did in Experiment 1. Finally, we employed the same data-exclusion criteria that were adopted in Experiment 1, again eliminating 1.6% of the data.

Results

Comprehension-question accuracy. Mean comprehension-question accuracies for each condition were as follows: Person-Argument (95%), Person-Adjunct (95%), Metonym-Argument (94%), Metonym-Adjunct (93%). As in Experiment 2, data were arcsine-transformed before calculating inferential statistics. There were no significant main effects or interactions.

Prenoun region. Mean reading times for the three regions of interest are displayed in Table 5. Reading times from all trials were included, regardless of whether the comprehension

question was answered correctly. No statistically significant main effects or interactions were observed in the prenoun region for gaze duration, right-bounded reading time, or regression-path duration, demonstrating that processing difficulty for the four conditions did not differ prior to encountering the critical NP.

In contrast, there was a main effect of NP type for total time that was significant in the subject analysis and marginal in the item analysis, $F_1(1, 43) = 7.56$, $MSE = 22{,}131$, $p < .01$; $F_2(1, 31) = 3.16$, $MSE = 43{,}626$, $p < .09$, indicating that there were longer reading times on the prenoun region when the critical NP was a metonym compared to when it was a person. There was no main effect of sentence structure, $F_1(1, 43) = 1.67$, $MSE = 28{,}403$, $p > .20$; $F_2(1, 31) = 2.26$, $MSE = 17{,}095$, $p > .14$, nor was there an interaction between NP type and sentence structure, $F_1(1, 43) = 1.22$, $MSE = 29{,}218$, $p > .25$; $F_2(1, 31) = 1.56$, $MSE = 19{,}425$, $p > .20$.

Critical NP. Analysis of gaze duration on the critical NP revealed no significant main effects or interactions, all *p*s > .10.

There was a main effect of NP type in right-bounded reading time, $F_1(1, 43) = 20.73$, $MSE = 5{,}946$, $p < .001$; $F_2(1, 31) = 5.67$, $MSE = 16{,}560$, $p < .05$,with longer reading times on metonymic NPs compared to NPs that named people. The main effect of sentence structure was not significant, $F_1(1, 43) < 1$; $F_2(1, 31) < 1$. However, the interaction between NP type and sentence structure was marginally significant in the subject analysis and fully significant in the item analysis, $F_1(1, 43) = 2.70$, $MSE = 6{,}746$, $p = .10$; $F_2(1, 31) = 5.56$, $MSE = 2{,}785$, $p < .05$. Follow-up comparisons revealed that metonymic NPs were more difficult to process than people NPs when they appeared as an argument of the verb, $t_1(43) = 5.24$, $p < .001$; $t_2(31) = 3.04$, $p < .01$, but that there was no difference when the critical NP appeared as part of an adjunct phrase, $t_1(43) = 1.67$, $p > .10$; $t_2(31) = 1.33$, $p > .19$.

Table 5
Results of Experiment 2.

Measure (in milliseconds)	Prenoun region	Critical NP	Postnoun region
Person-Argument	*journalist offended*	*the leader*	*after he had*
Person-Adjunct	*journalist offended* (*the honor of*)	*the leader*	*after he had*
Metonym-Argument	*journalist offended*	*the college*	*after he had*
Metonym-Adjunct	*journalist offended* (*the honor of*)	*the college*	*after he had*
Gaze duration			
Person-Argument	520	341	404
Person-Adjunct	522	349	368
Metonym-Argument	536	362	378
Metonym-Adjunct	551	364	376
Right-bounded reading time			
Person-Argument	620	398	439
Person-Adjunct	620	411	408
Metonym-Argument	635	471	462
Metonym-Adjunct	645	444	429
Regression-path duration			
Person-Argument	664	515	481
Person-Adjunct	661	583	476
Metonym-Argument	670	585	570
Metonym-Adjunct	699	590	477
Total time			
Person-Argument	1,032	597	629
Person-Adjunct	1,093	602	590
Metonym-Argument	1,122	724	677
Metonym-Adjunct	1,126	669	601

Note. NP = noun phrase.

Regression-path duration on the critical NP did not show significant main effects of sentence structure or NP type. Again, however, the interaction between these two factors was significant in the item analysis, $F_1(1, 43) = 1.77$, $MSE = 25{,}147$, $p > .15$; $F_2(1, 31) = 4.95$, $MSE = 10{,}778$, $p < .05$. Follow-up contrasts again showed that metonymic NPs were more difficult to process than people NPs when they appeared as an argument of the verb, $t_1(43) = 2.21$, $p < .05$;

$t_2(31) = 2.01$, $p = .05$, but that there was no difference when the critical NP appeared as part of an adjunct phrase, ts < 1.

Analysis of total time on the critical NP revealed a robust effect of NP type, such that metonymic NPs were more difficult than people NPs, $F_1(1, 43) = 35.49$, $MSE = 11{,}686$, $p < .001$; $F_2(1, 31) = 8.21$, $MSE = 38{,}248$, $p < .01$. Once again, there was a marginally significant interaction between NP type and sentence structure, $F_1(1, 43) = 2.89$, $MSE = 13{,}383$, $p < .10$; $F_2(1, 31) = 3.35$, $MSE = 8{,}923$, $p < .08$. Metonymic NPs were more difficult than people NPs regardless of whether the NP appeared as an argument of the verb, $t_1(43) = 4.71$, $p < .001$; $t_2(31) = 3.08$, $p < .005$, or as part of an adjunct, $t_1(43) = 3.31$, $p < .005$; $t_2(31) = 2.00$, $p = .05$. In contrast, there was evidence (in the subject analysis) that metonymic NPs were more difficult as arguments than adjuncts, $t_1(43) = 2.10$, $p < .05$; $t_2(31) = 1.46$, $p > .15$, but there was no such difference for people NPs, ts < 1.

Thus, measures of right-bounded reading time and total time on the critical NP showed main effects of NP type such that familiar metonyms were more difficult to process than NPs that named people. These main effects were qualified by interactions in measures of right-bounded reading time, regression-path duration, and total time on this region showing that metonyms were more difficult to process when they appeared as the argument of the verb than when they appeared as part of an adjunct phrase, but that there was no such effect of sentence structure on the processing of people NPs.

Postnoun region. Analysis of gaze duration on the postnoun region revealed a main effect of sentence structure (marginal in the item analysis), $F_1(1, 43) = 4.15$, $MSE = 3.782$, $p < .05$; $F_2(1, 31) = 3.46$, $MSE = 5{,}821$, $p < .08$, with longer reading times on arguments than adjuncts. There was no main effect of NP type; however, the interaction between NP type and sentence

structure was marginally significant in the subject analysis, $F_1(1, 43) = 3.52$, $MSE = 3{,}911$, $p < .07$; $F_2(1, 31) < 1$. This pattern was driven by longer gaze durations in the condition where a person NP appeared as an argument of the verb, relative to the other three conditions.[7]

Right-bounded reading time showed a main effect of sentence structure on the postnoun region, such that arguments were overall more difficult than adjuncts, $F_1(1, 43) = 6.01$, $MSE = 7{,}622$, $p < .05$; $F_2(1, 31) = 5.16$, $MSE = 8{,}535$, $p < .05$. The main effect of NP type and the interaction between NP type and sentence structure were not significant.

There was a fully significant interaction between NP type and sentence structure in regression-path duration on the postnoun region, $F_1(1, 43) = 4.29$, $MSE = 19{,}457$, $p < .05$; $F_2(1, 31) = 4.25$, $MSE = 15{,}445$, $p < .05$. Follow-up contrasts revealed that metonymic NPs were more difficult to process than people NPs when they appeared as the object of the verb, $t_1(43) = 2.62$, $p < .05$; $t_2(31) = 2.87$, $p < .01$, but not when they appeared as part of an adjunct phrase, ts < 1. Furthermore, metonymic NPs were more difficult to process as arguments than adjuncts, $t_1(43) = 2.81$, $p < .01$; $t_2(31) = 2.86$, $p < .01$, whereas there was no such difference for people NPs, ts < 1.

[7] The pattern observed on this gaze-duration measure is reversed when the more encompassing measure of regression-path duration is explored, a change which suggests differences across conditions in the likelihood that the eyes moved forward after first-pass reading of the postnoun region. This suggestion was born out by the finding that the proportion of trials with first-pass regressions from this region was lowest in the Person-Argument condition (i.e., 9%, compared with 21%, 11%, and 14% in the Metonym-Argument, Person-Adjunct, and Metonym-Adjunct conditions, respectively). Further, both the number of first-pass fixations on the postnoun region and their summed durations were greater on trials followed by progressive saccades than by regressive saccades [number of fixations: $F_1(1, 43) = 27.36$, $MSE = 0.55$, $p < .001$; $F_2(1, 31) = 68.74$, $MSE = 0.21$, $p < .001$; gaze duration: $F_1(1, 43) = 13.88$, $MSE = 44{,}479$, $p < .01$; $F_2(1, 31) = 40.62$, $MSE = 16{,}054$, $p < .001$]. This difference is readily explained as due to readers prematurely terminating their first-pass reading of the postnoun region in order to return to an earlier region of text when they experienced difficulty understanding the meaning of those earlier regions. This difficulty was least likely to be experienced in the Person-Argument condition, which could have the paradoxical effect of elevating average gaze durations for that region relative to the others. This account was tested by analyzing gaze duration on the postnoun region only for those trials where the eyes progressed after first-pass reading of the postnoun region. Restricting the analysis in this way completely eliminated the interaction between NP type and sentence structure, $F_1(1, 43) < 1$; $F_2(1, 31) < 1$.

We also analyzed skipping rates on the critical NP to examine the possibility that the longer gaze durations in the postnoun region for the Person-Argument condition may have been the result of different fixation patterns for this condition compared to the other conditions. Skipping rates were as follows: Person-Argument (2%), Metonym-Argument (3%), Person-Adjunct (4%), Metonym-Adjunct (5%). There were no significant main effects or interactions.

Thus, participants were more likely to experience processing difficulty in the region immediately following the critical NP when the NP was a metonym that appeared as an argument, compared to the other three conditions.

Total time on the postnoun region showed a main effect of sentence structure, such that arguments were more difficult than adjuncts, $F_1(1, 43) = 11.17$, $MSE = 12{,}956$, $p < .005$; $F_2(1, 31) = 7.23$, $MSE = 15{,}984$, $p < .05$. The main effect of NP type and the interaction between NP type and sentence structure were not significant.

Discussion

Experiment 2 replicated the finding from Experiment 1 that metonyms are harder to process than literal expressions. Whereas Experiment 1 compared familiar metonyms that were used in their figurative sense (e.g., *offended the college*) versus their literal sense (e.g., *photographed the college*), Experiment 2 compared familiar metonyms to nouns that referred directly to people (e.g., *offended the leader*).

Critically, Experiment 2 also demonstrated that the degree of processing difficulty depends on sentence structure. Readers experienced greater difficulty with metonymic nouns than nouns that named people when the critical NP appeared as the object of the verb. In contrast, when the critical NP appeared as part of an adjunct phrase, the processing difference between metonyms and people was reduced or eliminated completely. There was evidence for this interaction effect on the critical NP itself in right-bounded reading time, regression-path duration, and total time; however, the effect was strongest in regression-path duration on the postnoun region, indicating a tendency for participants to experience greater processing difficulty for the Metonym-Argument condition than the other three conditions in the region immediately following the metonym and then spend extra time going back to reread earlier parts of the

sentence. Our finding of reduced difficulty for the processing of metonyms that appear as part of an adjunct phrase is consistent with the pattern of effects predicted by a direct-access model of figurative-language processing.

We propose that metonyms are especially difficult to process when they appear as the argument of a verb because this position is focused by the sentence structure. Given the verb *offended*, the reader needs to understand who offended whom in order to obtain a basic understanding of the sentence. In this case, the "whom" is an inanimate noun used metonymically (*college*), which requires a noncanonical interpretation, leading to extra processing. In contrast, when the object of the verb is a noun that represents a human characteristic (*honor*), this becomes a focus of the sentence, whereas the adjunct phrase (*of the college*) is less important and thus is not processed as deeply. As noted above, the Adjunct condition contained two sources of semantic information that pointed to the need to interpret the critical NP as having animate qualities (e.g., *offended the honor of the college*), whereas the Argument condition contained only one (e.g., *offended the college*). It could be argued that this extra semantic material—not the difference in sentence structure—causes the reduction in processing difficulty. Although the current experiment does not rule out this possibility, it is not obvious how the mere presence of two sources of semantic information should lead to easier processing. In fact, it could also be argued that two sources of semantic information would have the opposite effect, leading the reader to more strongly expect an animate patient, thereby highlighting the incongruity of a metonymic target word rather than facilitating its figurative interpretation. The presence of additional semantic material might aid figurative-language processing in cases where it helps identify the needed figurative interpretation rather than simply reinforcing the need for such an interpretation. That sort of facilitation may be operating in the

Adjunct condition, where the structure of the sentence serves to direct the reader's attention toward a particular feature of the metonym (e.g., *honor*), while deemphasizing the metonym itself.

General Discussion

This study produced three main findings. First, Experiment 1 showed that familiar metonyms are more difficult to process when they appear in a figurative context (e.g., *offended the college*) than when they appear in a literal context (e.g., *photographed the college*)—an effect that emerged early in the eye-tracking record. Differences in the processing of familiar metonyms versus unfamiliar metonyms (e.g., *offended the pyramid*) did not emerge until late in the eye-tracking record. Second, Experiment 2 showed that the difficulty associated with processing a familiar metonym (e.g., *offended the college*) also emerges when compared against a noun that explicitly names a person (e.g., *offended the leader*). Finally, our results demonstrate that the difficulty of processing a familiar metonym was reduced when it appeared as part of an adjunct phrase (e.g., *offended the honor of the college*) compared to when it appeared as an argument of the verb. These findings show that the pattern of performance predicted by the indirect-access model of figurative-language processing is found for metonyms that are arguments but that the pattern of performance predicted by the direct-access model of figurative-language processing is found for metonyms that are adjuncts.

Findings on Metonymic Processing

Previous research on the processing of metonymy has produced inconsistent results, with some studies showing that familiar metonyms are no more difficult to process than literal expressions and others showing that they are more difficult. While these studies have employed

a variety of different methods and have used stimuli that differ on a number of dimensions, we believe that the moderating effect of sentence structure on metonymic processing offers a new perspective on how figurative language is processed and helps explain previous inconsistencies in the literature. As discussed previously, Frisson and Pickering (1999) found only weak evidence that familiar metonyms (e.g., *rejected by the college*) are more difficult to process than literal expressions (e.g., *stepped inside the college*), but their target words sometimes appeared as an argument of the verb and sometimes appeared as part of an adjunct phrase. The results of the current study suggest that the weak effects reported by Frisson and Pickering, and of other experiments using the same materials (Humphrey et al., 2004), might be due to structural variation within their materials. In sentences where the critical word was an argument, metonymic interpretation may have been more difficult than literal interpretation, whereas it was not so in sentences where the critical word was an adjunct, with this second type of sentence structure diluting the impact of the first. Variation in sentence structure might also account for the absence of differences in the processing of literal expressions and familiar place-for-event or producer-for-product metonyms (Frisson & Pickering, 1999, Experiment 2; Frisson & Pickering, 2007). In contrast, studies demonstrating greater difficulty in the processing of metonymic and literal expressions (Gibbs, 1990; Rapp et al., 2011; Weiland et al., 2012) have tended to use target nouns as arguments of the predicates that induced the metonymic or literal interpretation (e.g., *The scalpel was sued for malpractice*; *The glove at third base has to be replaced*; Gibbs, 1990).

Nonetheless, it is important to note that using the same method as the current studies, eye-tracking during reading, McElree et al. (2006) found no evidence of difficulty in comprehension of producer-for-product metonyms (e.g., *The gentleman read Dickens…*) as

compared to literal controls (e.g., *The gentleman spotted Dickens…*) even though the critical word consistently appeared as the object of the context-providing verb. The discrepancy between this finding and those reported here is unlikely to be due to the use of different types of metonyms (producer-for-product versus place-for-institution) as studies using other methods have shown difficulty in processing producer-for-product metonyms that appear as arguments (Rapp et al., 2011; Weiland et al., 2012). One possible explanation is that the discrepancy is due to greater difficulty in processing the literal sentences in McElree et al.'s study as compared to those reported here. McElree et al.'s literal condition consisted of people interacting with famous deceased writers (e.g., *The educated slave greeted Aristotle…*; *The retired professor welcomed Freud…*), whereas those in the current study involved conventional action-place pairings (e.g., *photographed the college*; *entered the academy*; Experiment 1) or human role terms that matched the metonyms in length and frequency (*offended the leader*; *addressed the secretary*; Experiment 2). Further research will be needed to determine whether this explanation is valid or whether the discrepancy has some other basis. Though they found no evidence of difficulty in metonymic processing, McElree et al. did find greater difficulty when understanding required object-for-event coercion (e.g., *The gentleman started Dickens…*versus *The gentleman read Dickens…*). Thus, the McElree et al. pattern of results presents a challenge to our proposal that comprehension of figurative language, whether it involves coercion or metonymy, is difficult because of the need to derive a noncanonical interpretation of a word that allows it to make sense in the context. The degree of processing difficulty might vary with the type of figurative language or for particular expressions, but this processing difficulty should be present to some degree when the figurative expression appears as a sentential argument.

Sentence Structure and Metonymic Processing

Several psycholinguistic accounts have proposed that sentence structure is one important cue that helps guide language processing and indicates to the comprehender which elements of the sentence should be processed more deeply than others (e.g., Baker & Wagner, 1987; Ferreira et al., 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002). We have argued that the pairing of an inanimate subject with an action verb (e.g., *the pistol injured*) or the use of a metonym as the object of a verb (e.g., *offended the college*) cause processing difficulty because the structure of the sentence promotes deep interpretation of a verbal predicate in relation to its arguments, which in these examples requires a noncanonical semantic interpretation of the argument. In particular, a verb such as *offend* typically requires an object that is human—capable of perceiving some wrongdoing and experiencing a negative emotional reaction. When instead an inanimate place such as *the college* appears as the object, the comprehender must search for an alternate meaning of this word that satisfies the semantic requirements of the verb. Accordingly, the comprehender comes to interpret *the college* not as a literal physical place, but rather as an institution made of humans who experienced offense. Importantly, this search for an appropriate meaning of *offended the college* requires additional processing time in comparison to when the object is a human (e.g., *offended the leader*) or when the verb selects an argument that is consistent with the literal meaning of the metonym (e.g., *photographed the college*). Similarly, *honor* can easily serve as the object of *offended*. Although not animate *per se*, *honor* refers to a human value that can suffer offense. Thus, in the phrase *offended the honor of the college*, the word *honor* becomes closely tied to the action *offend*, whereas *of the college* is a modifier of *honor* that is not tightly bound to the main verb of the sentence, and so it is processed less deeply.

In sum, we propose that syntactic structure is an important aspect of a sentence that guides processing and provides cues as to which constituents are more important than others. When the structure of the sentence places a metonym in a focused position, such as the object of the verb, the comprehender will experience enhanced semantic difficulty due to the need to derive a noncanonical interpretation of this word. In contrast, adjunct phrases are not as important to the overall meaning of the sentence, and so a metonym in an adjunct phrase is typically not processed at a deep semantic level.

We believe that there are several possible mechanisms that might account for this pattern of effects. First, in line with Frisson and Pickering's account (Frisson, 2009; Frisson & Pickering, 1999, 2001), it may be that when a metonym appears in an adjunct phrase the reader does not fully distinguish between literal and figurative interpretations initially, but rather adopts a semantically underspecified representation and, if necessary, selects the intended meaning at a later stage of processing. Because the information contained in an adjunct phrase is seen as less important to the overall meaning of the sentence, it is possible that an underspecified interpretation is sufficient in most cases. A second possibility is that explicit mention of a feature of the metonym (e.g., *honor* in *offended the honor of the college*) makes that feature particularly salient, thereby reducing focus on the metonym itself. From this perspective, *honor* is a known but not usually a primary characteristic of a college. By promoting this property to a prominent position in the sentence, the comprehender becomes particularly focused on this now-salient aspect of *college* at the expense of processing the information in the adjunct. Finally, the basic structure of an adjunct seems to indicate that the information it conveys is presupposed. That is, a phrase such as *of the college* implies that *the college* has already been brought into the discourse (i.e., is "given") and is now appearing in the sentence simply to modify a new entity

(e.g., *the honor*). The use of a definite rather than an indefinite article may further suggest that the critical word is presupposed; however, the definite article was also used in the Argument conditions. Thus, any influence from the article indicating that the critical word was presupposed was consistent across all conditions. We propose that the structure of the adjunct phrase is an additional source of information that may cue the reader that the information it conveys is presupposed, as it is being presented not as a focal point of the sentence, but rather as a modifier. Underspecification of meaning, promotion of a relevant property, and presupposition are all ways that sentence structure may cause a noncanonical semantic interpretation to be processed less deeply. These explanations are not necessarily mutually exclusive; each may explain some aspect of reduction in depth of processing.

Conclusion

Debates over how figurative language is processed have shifted from accounts where a literal interpretation must be accessed before a figurative interpretation (e.g., Clark & Lucy, 1979; Grice, 1975; Janus & Bever, 1985; Searle, 1979) to accounts where familiar figurative expressions do not require extra processing effort (e.g., Gerrig & Healy, 1983; Gibbs, 1994; Gibbs & Gerrig, 1989; Gildea & Glucksberg, 1983; Glucksberg, 1991, 2003; Glucksberg et al., 1982; Keysar, 1989; Inhoff et al., 1984; Ortony et al., 1978; Shinjo & Myers, 1987), with most of this research investigating the processing of metaphor. More recent studies investigating other types of language have provided growing evidence that figurative expressions often tend to be more difficult to process than literal expressions. These include studies on the processing of idioms (Cacciari & Tabossi, 1988), proverbs (Honeck, Welge, & Temple, 1998; Temple & Honeck, 1999), and irony (Dews & Winner, 1999; Giora, Fein, & Schwartz, 1998; Filik & Moxey, 2010; Schwoebel, Dews, Winner, & Srinivas, 2000). Even in the realm of metaphor,

several recent studies using electrophysiology have suggested that the processing of metaphorical expressions is more effortful than the processing of literal expressions (Coulson & Van Petten, 2002, 2007; De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010; Lai, Curran, & Menn, 2009; Tartter, Gomes, Dubrovsky, Molholm, & Stewart, 2002). The results of the current study corroborate and extend these previous findings in demonstrating that metonyms—both familiar and unfamiliar—are more difficult to process than literal expressions when they are arguments of the predicate that induces the metonymic interpretation. Importantly, the difficulty associated with processing a familiar metonym was reduced when it appeared in a position that is less central to the structure of the sentence. These findings indicate that sentence structure is a key factor to consider in developing psycholinguistic models that explain the processing of figurative language.

Transition to Chapter 4

As discussed above, the processing difficulty associated with integrating an inanimate subject with an action verb (e.g., *The pistol injured the cowboy*; Lowder & Gordon, 2012) could have multiple possible sources. Expressions like these have been proposed to require a *metonymic* interpretation (Gibbs, 1990; Lakoff & Johnson, 1980), in which the inanimate object is used figuratively to refer to the person who was using the object (e.g., "The pistol" to refer to "The man who was carrying the pistol"). However, other work has proposed that successful interpretation of these expressions requires a process of *subject-type coercion* (Pustejovsky, 1995; Pustejovsky, Anick, & Bergler, 1993), in which the inanimate subject is type-shifted from an entity to an event (e.g., "The pistol" to refer to "Someone's shooting of the pistol").

Closely related to the notion of subject-type coercion is *complement coercion*, which has been described as a linguistic phenomenon which allows an event-selecting verb (e.g., *begin, finish, enjoy*) to combine with a complement NP that represents an entity (e.g., *began the book*) rather than an event (e.g., *began the hike*). Many experiments implementing a wide array of methodologies have demonstrated that expressions requiring complement coercion are more difficult to process than a variety of controls (e.g., Kuperberg et al., 2010; McElree et al., 2001; Pylkkänen & McElree, 2007; Scheepers et al., 2008; Traxler et al., 2002). Importantly, however, previous studies on the processing of complement coercion have only considered sentences in which the entity-denoting NP whose meaning must be coerced is the direct object of the event-selecting verb (e.g., *The author finished the book*; *The secretary began the memo*). Given that this sort of complex semantic construction has similarities to inanimate subject-verb integration and metonymy, it may also be the case that its processing difficulty is modulated in ways that are similar to what we have observed previously (Lowder & Gordon, 2012, 2013).

In our previous work (Lowder & Gordon, 2012, 2013), we showed that inanimate subject-verb integration is difficult when the two constituents appear together in the same clause of a sentence (e.g., *The sheriff that the pistol injured; The pistol injured the cowboy*) but that this difficulty is reduced when the subject and target verb appear in separate clauses (e.g., *The pistol that injured the cowboy*). Similarly, we showed that the figurative sense of a metonym is difficult to process when it appears as the object of the context-inducing verb (e.g., *The journalist offended the college*) but that this difficulty is reduced when the metonym appears as part of an adjunct phrase (e.g., *The journalist offended the honor of the college*). In Lowder and Gordon (under review), we investigate whether sentence structure moderates the magnitude of the coercion cost in the same way that it moderates the processing difficulty associated with these other types of complex semantic expressions. In addition, we test whether the effect of sentence structure on the magnitude of the coercion cost depends on structural emphasis or deemphasis of specific constituents or on the structural relationship between the critical linguistic elements that require complex semantic interpretation.

CHAPTER 4: Lowder and Gordon (under review)

Sometimes the intended meaning of a sentence cannot be composed from the meanings of its words and the syntactic relations between them but instead must be attained in a less well specified manner such as adopting a figurative interpretation. Psycholinguists have extensively debated how the processing of such *semantically complex expressions* is related to the processing of more literal language. An early account of figurative-language processing was the *standard pragmatic model* (Grice, 1975; Searle, 1979), which was characterized by psycholinguists as an *indirect-access model* (e.g., Clark & Lucy, 1975; Janus & Bever, 1985; for reviews, see Glucksberg, 1991, 2001, 2003). According to the indirect-access model, the processing of semantically complex expressions involves the following steps: (1) the comprehender computes the literal meaning of an expression using the stored meanings of lexical entries; (2) the comprehender determines whether the literal meaning of the expression seems appropriate in the broader sentence context or whether it instead seems "defective" (Searle, 1979); and (3) if the literal meaning is defective, the comprehender searches for an alternative meaning. The indirect access model thus predicts longer processing times for nonliteral or noncanonical expressions, compared to literal expressions.

Although the indirect-access model received some early empirical support, later studies found that semantically complex meanings can be computed rapidly given a sufficiently supportive context (Gerrig & Healy, 1983; Frisson & Pickering, 1999; Inhoff, Lima, & Carroll, 1984; Ortony, Schallert, Reynolds, & Antos, 1978; Shinjo & Myers, 1987) and in some cases may be activated before a literal interpretation (Gildea & Glucksberg, 1983; Glucksberg, Gildea,

& Bookin, 1982; Keysar, 1989). Given these findings, the indirect-access model was challenged by a *direct-access model* (Gibbs, 1994; Gibbs & Gerrig, 1989; Glucksberg, 1991, 2003), according to which comprehenders use contextual information to immediately select the intended meaning of a word or expression, so that priority in processing is not necessarily given to either the literal or semantically complex interpretation. While these findings led many psycholinguists to see the indirect-access model as discredited, a number of studies investigating a variety of figurative language forms have continued to produce patterns of results that are consistent with its prediction that semantically complex expressions should take more time to process than literal expressions (e.g., Coulson & Van Petten, 2002, 2007; De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010; Dews & Winner, 1999; Filik & Moxey, 2010; Giora, Fein, & Schwartz, 1998; Honeck, Welge, & Temple, 1998; Lai, Curran, & Menn, 2009; Lowder & Gordon, 2012, 2013; Schwoebel, Dews, Winner, & Srinivas, 2000; Tartter, Gomes, Dubrovsky, Molholm, & Stewart, 2002; Temple & Honeck, 1999). These findings indicate that evidence about processing time does not necessarily lead to a rejection of the indirect-access model (cf. Gluscksberg, 1991, 2003), though they do leave open the possibility that other mechanisms might account for the effects. Further, the key features of the indirect-access model have been incorporated into explanations of a different type of semantic complexity – *complement coercion*.

Complement Coercion

Complement coercion occurs when a verb that requires an event-denoting complement (e.g., *began, finish, enjoy*) is paired with a noun phrase (NP) that refers to an object or other entity rather than an event (Jackendoff, 1997; Pustejovsky, 1995). For example, the complement NP *the hike* in (1a) represents an event, and so it matches the semantic requirements of the verb *began*. In contrast, the complement NP *the book* in (1b) represents an entity, and thus constitutes

a semantic mismatch. Complement coercion is the process in which this entity comes to be interpreted as an event so as to satisfy the semantic constraints of the verb. Note that the meaning of (1b) could plausibly correspond to any of the meanings depicted in (1c).

1a. Mary began the hike.

1b. Mary began the book.

1c. Mary began [reading, writing, reviewing, publishing, translating, editing] the book.

In an early experiment on the processing of complement coercion, Traxler, Pickering, and McElree (2002) recorded participants' eye movements as they read sentences like those in (2). In this design, (2a) contains the expression that must undergo coercion, whereas (2b) and (2c) are control sentences representing both a preferred and non-preferred interpretation. Traxler et al. showed that there was substantial processing difficulty associated with the coercion condition (2a) compared to the other conditions (2b and 2c) as shown by longer regression-path durations on the region immediately following the complement NP, as well as in later measures reflecting more rereading of the verb, the complement NP, and the post-noun region.

2a. The secretary began the memo about the new office policy. (coercion)

2b. The secretary wrote the memo about the new office policy. (preferred)

2c. The secretary typed the memo about the new office policy. (non-preferred)

Traxler et al. further showed that the cost of complement coercion did not result simply from pairing an event-selecting verb with an NP regardless of the semantic relationship between the two constituents; that is, greater processing difficulty was observed when an event-selecting verb took an entity NP as its complement (e.g., *The boy started the puzzle*) as compared to a neutral-verb condition (e.g., *The boy saw the puzzle*), but there was no evidence of processing difficulty

when the event-selecting verb combined with an NP that represented an event (e.g., *The boy started the fight*) compared to the control condition (e.g., *The boy saw the fight*).

Additional experimental research has consistently demonstrated that complement coercion imposes an online processing cost in comparison to a variety of control conditions (for reviews, see Pylkkänen, 2008; Pylkkänen & McElree, 2006), with coercion costs seen using a broad range of methods: self-paced reading (McElree, Traxler, Pickering, Seely, & Jackendoff, 2001), eye-tracking during reading (Frisson & McElree, 2008; McElree, Frisson, & Pickering, 2006; Pickering, McElree, & Traxler, 2005; Traxler, McElree, Williams, & Pickering, 2005; Traxler, Pickering, & McElree, 2002), eye-tracking in the visual-world paradigm (Scheepers, Keller, & Lapata, 2008), speed-accuracy trade-off (McElree, Pylkkänen, Pickering, & Traxler, 2006), electrophysiology (Baggio, Choma, van Lambalgen, & Hagoort, 2010; Kuperberg, Choi, Cohn, Paczynski, & Jackendoff, 2010), magnetoencephalography (Pylkkänen & McElree, 2007), and functional MRI (Husband, Kelly, & Zhu, 2011).

Accounts of the difficulty in processing complement coercion build on the linguistic proposal that the combination of an event-selecting verb and an entity-denoting NP (e.g., *began the memo*) constitutes a semantic mismatch that requires that the entity-denoting NP be interpreted instead as an event (*type-shifted*) to satisfy the semantic constraints of the verb (Jackendoff, 1997; Pustejovsky, 1995). Traxler, McElree, et al. (2005, p. 4) propose that this occurs through the following sequence of processing operations: (1) access of the stored lexical entry for the complement noun (e.g., *memo*) and an initial attempt to integrate its meaning with the unfolding meaning of the sentence; (2) detection of a mismatch between the stored semantic characteristics of the noun and the thematic properties of the verb, which triggers the coercion process; (3) an attempt to resolve the semantic mismatch by using the context of the sentence to

infer an action that could plausibly be performed on the noun; and (4) reconfiguration of the semantic properties of the complement to allow for an event interpretation. Although not explicitly characterized as such, Traxler et al.'s account of the processing of coercion closely resembles the indirect-access model of figurative-language processing, which likewise involves an initial attempt to establish meaningful relations based on stored senses of a word, detection of a semantic mismatch (a "defect" in Searle's terminology) when this initial interpretation fails, and a process of using contextual information to resolve the mismatch and ultimately arrive at the intended meaning.

A slightly different account put forth by Pylkkänen and McElree (2006; see also Pylkkänen, 2008) emphasizes that the type mismatch between the properties of the noun and verb effectively blocks the application of basic compositional operations, thereby triggering the costly type-shifting process of coercion. Further, Pylkkänen and McElree argue that this account helps explain why processing costs are observed for expressions requiring complement coercion but not for other types of complex semantic expressions such as metonymy, which are proposed to involve a mismatch of "sorts" rather than a mismatch of "types" (see Pylkkänen, 2008; Pylkkänen & McElree, 2006, for a discussion). However, as we discuss below, the claim that familiar metonymic expressions are no more difficult to process than literal expressions (e.g., Frisson & Pickering, 1999, 2007; Humphrey, Kemper, & Radel, 2004) has been disputed on the grounds that previous studies on the processing of metonymy have failed to adequately control for sentence structure, which can have a strong moderating effect on the difficulty associated with processing complex semantic expressions.

Sentence Structure and Interpretation of Semantic Relationships

Our recent work (Lowder & Gordon, 2012, 2013) has shown that the difficulty of complex semantic interpretation is moderated by the structural relation between the expressions that together create the need for complex semantic interpretation; processing difficulty is observed when those expressions appear in a within-clause predicate-argument relationship but not when they are related by a prepositional phrase or by modification with a relative clause. This effect was demonstrated first in studies on subject-verb integration that compared reading times for an action verb paired with an animate subject (e.g., *The sheriff injured the cowboy*) as compared to an inanimate subject (e.g., *The pistol injured the cowboy*) (Lowder & Gordon, 2012). Readers experienced greater difficulty processing the verb when the sentence subject was inanimate versus animate, with this effect emerging both when the subject-verb pair appeared together in the main clause of the sentence as well as when the two constituents appeared together inside a relative clause (e.g., *The sheriff that the pistol injured* versus *The sheriff that the cowboy injured*). However, this processing difficulty was reduced or eliminated when the action verb was embedded in a relative clause that modified the inanimate subject (e.g., *The pistol that injured the cowboy* versus *The sheriff that injured the cowboy*).

Lowder and Gordon (2013) found a comparable effect for the processing of *metonymy*, a figurative form where reference to an entity is made through the name of some other entity that is intimately associated with it. When a familiar place-for-institution metonym appeared as the object of a verb in a figurative context (e.g., *The journalist offended the college*), readers experienced greater processing difficulty than when the metonym appeared in a literal context (e.g., *The journalist photographed the college*) or when the object of the verb was animate (e.g., *The journalist offended the leader*). However, this processing difficulty was reduced when the

metonym appeared as part of an adjunct phrase (e.g., *The journalist offended the honor of the college*). Previous work suggesting that familiar metonyms are no more difficult to process than literal expressions (Frisson & Pickering, 1999, 2007; Humphrey et al., 2004) had evaluated sets of stimuli that included cases where the metonym was the object of the verb, as well as cases where the metonym was in a locative or other adjunct phrase, with this mix of sentence types possibly reducing the sensitivity of the experiments in detecting the processing difficulty associated with familiar metonyms.

The pattern of results in these two studies (Lowder & Gordon, 2012, 2013) shows that complex semantic expressions are difficult to process when there is a within-clause predicate-argument relationship between the relevant constituents. These results are consistent with the basic predictions of the indirect-access model, according to which an initial attempt is made to integrate stored lexical entries with the unfolding meaning of the sentence, which leads to detection of a semantic mismatch and a search for an alternative meaning. A "semantic mismatch" under this account could be due to a mismatch that occurs when an inanimate subject is paired with an action verb that requires an animate subject (e.g., *The pistol injured the cowboy*; Lowder & Gordon, 2012), a mismatch that occurs when a psychological verb that requires an experiencer object is paired with an object that refers to a non-human place (e.g., *The journalist offended the college*; Lowder & Gordon, 2013), or a mismatch that occurs when a verb that requires an event NP is paired with an NP that refers to an entity (e.g., *The secretary began the memo*; McElree et al., 2001; Traxler et al., 2002). When a complex semantic expression is established across a clause boundary or with a prepositional phrase, processing difficulty is reduced (Lowder & Gordon, 2012, 2013)—an effect that may be related to the likelihood of detecting the mismatch, the process of searching for an alternative meaning, or both. These

possibilities are consistent with a range of findings showing that sentence structure influences the depth at which language is processed (e.g., Baker & Wagner, 1987; Ferreira, Bailey, & Ferraro, 2002; Gordon & Hendrick, 1998; Sanford & Sturt, 2002).

Current Experiments

The indirect-access model outlines a process where an initial literal interpretation is evaluated and altered if necessary. This general process can be applied to different types of complex semantic relationships even though the precise mechanisms that allow for detection and resolution of different types of semantic mismatches are likely to vary. Like inanimate subject-verb integration and metonymy, complement coercion involves mismatch in the meanings of expressions that should be related in order for a sentence to be understood. Indeed, some combinations of inanimate entities with action verbs of the sort studied by Lowder and Gordon (2012) (e.g., *The pistol injured the cowboy*) have been analyzed as requiring a process of *subject-type coercion* (Pustejovsky, 1995; Pustejovsky, Anick, & Bergler, 1993), in which the inanimate subject is type-shifted from an entity (e.g., *The pistol*) to an event (e.g., *Someone's shooting of the pistol*). Further, the stimuli used in psycholinguistic research on complement coercion have exclusively involved sentences in which the entity-denoting NP whose meaning must be coerced is the direct object of the verb that requires an event as its complement (Baggio et al, 2009; Frisson & McElree, 2008; Husband et al., 2011; Kuperberg et al., 2010; McElree et al., 2001; McElree, Frisson, & Pickering, 2006; McElree, Pylkkänen, et al., 2006; Pickering et al., 2005; Pylkkänen & McElree, 2007; Scheepers et al., 2008; Traxler, McElree, et al., 2005; Traxler, Pickering, & McElree, 2002). The current experiments investigate whether sentence structure moderates the magnitude of coercion cost in the same way that it moderates the processing difficulty associated with other types of complex semantic expressions (Lowder & Gordon,

2012, 2013). Obtaining this pattern would be consistent with our prediction that sentence structure moderates the basic process of detecting and/or resolving a semantic mismatch for a range of semantic complexities that includes coercion and metonymy. In addition, these experiments test whether the effect of sentence structure on the magnitude of the coercion cost depends on structural emphasis or deemphasis of specific constituents or on the structural relationship between the critical linguistic elements that require complex semantic interpretation.

Experiment 1

Linguistic expressions in a defocused portion of a sentence, such as a relative clause or other adjunct phrase, are processed at a shallower level than information presented in the main clause of the sentence. For example, false information is detected more readily when it is presented in a sentence's main clause rather than in a subordinate clause (Baker & Wagner, 1987; see also Bredart & Modolo, 1988). Thus, the coercion cost might be reduced when the critical verb and complement NP appear together in an embedded clause compared to when they appear together in a simple one-clause sentence. Experiment 1 tested this possibility by varying whether the critical verbs and complement NPs appeared in the main clause of the sentence (e.g., 3a and 3b) or were in a subject-extracted relative clause (SRC; e.g., 3c and 3d).

3a. The secretary began the memo about the new office policy shortly after being hired. (Simple Sentence, Coercion)

3b. The secretary wrote the memo about the new office policy shortly after being hired. (Simple Sentence, Control)

3c. The secretary that began the memo about the new office policy had just been hired. (SRC, Coercion)

3d. The secretary that wrote the memo about the new office policy had just been hired. (SRC, Control)

Lowder and Gordon (2012, Experiment 1) showed that the processing of subject-verb integration is more difficult when an inanimate subject combines with an action verb, compared to when the subject is animate, even when both constituents appear together inside a relative clause. However, Lowder and Gordon did not directly assess whether the size of this processing cost differed when the two critical constituents appeared together in the main clause of the sentence compared to when they were embedded together in an RC. The current experiment allows the size of the coercion cost to be compared as a function of whether the critical verb and complement NP appear in the main clause of a simple-sentence context or are embedded in an RC. In addition, it allows for a direct test of whether readers in general spend more time processing linguistic information when it is in a main clause compared to when it is embedded in a subordinate clause. If sentence structure prompts shallower processing of semantic relations within embedded clauses, the coercion cost in the SRC condition (e.g., the difference between 3d and 3c) should be smaller than the coercion cost in the Simple-Sentence condition (e.g., the difference between 3b and 3a). Alternatively, while less time in general may be spent reading the constituents in the embedded as compared to the main clause, the process of computing the relationship between the verb and complement within the same clause may be the same regardless of the type of clause, leading to a constant coercion cost across the types of sentence structure.

Method

Participants. Thirty-six students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision.

Materials. Each participant was presented with 36 experimental sentences and 78 filler sentences. The experimental sentences (see example 3) were adapted from Traxler, Pickering, and McElree (2002, Experiment 1). In constructing the simple-sentence versions of each item, we used the same subject NP, verb, and complement NP used by Traxler et al. (e.g., *The secretary began/wrote the memo*). Whereas Traxler et al. had included verbs that represented the coercion, preferred, and non-preferred interpretation of each item (see example 2), we only included the coercion and preferred verbs. The sentence material following the complement NP was sometimes identical to the material used by Traxler et al., but was sometimes altered. The SRC versions of each item were created by inserting the complementizer *that* between the subject NP and verb and then rewriting the remainder of the sentence so that the meaning corresponded as closely as possible to the meaning of the simple-sentence versions. See Appendix A for the full set of experimental stimuli.

As noted by Traxler et al. (2002), the verbs in the coercion condition were longer on average than the verbs in the control condition. However, supplementary analyses that they conducted showed that this difference in length was not responsible for the different processing times observed for these two conditions. The two classes of verbs did not differ in frequency. In addition, Traxler et al. showed that their items did not differ in plausibility and that predictability of the complement NP was low across conditions.

The experimental sentences were counterbalanced across four lists so that each participant saw only one version of each item and so that each participant saw the same number of sentences from each of the four conditions.

Procedure. Participants' eye movements were recorded with an EyeLink 1000 system (SR Research) at a sampling rate of 1000 Hz, which was calibrated at the beginning of each session. A chinrest was used to minimize head movement. Participants were instructed to read at a natural pace. At the start of each trial, a fixation point was presented near the left edge of the monitor, marking the location where the first word of the sentence would appear. When the participant's gaze was steady on this point, the experimenter initiated presentation of the sentence. After reading the sentence, the participant pressed a button, which caused the sentence to disappear and a true-false comprehension question to appear in its place. Participants pressed one button to answer "true," and another key to answer "false." After the participant answered the comprehension question, the fixation point for the next trial appeared.

Participants were first presented with four of the filler sentences. After this warm-up block, the remaining 110 sentences were presented in a different random order for each participant.

Analysis. Data analysis focused on four standard eye-movement measures (see Clifton, Staub, & Rayner, 2007; Rayner, 1998). *Gaze duration* is the sum of all initial fixations on a region; it begins when the region is first fixated and ends when gaze is directed away from the region, either to the left or right (for multiword regions, this measure is commonly referred to as *first-pass reading time*). *Regression-path duration* (also called *go-past time*) is the sum of all fixations beginning with the initial fixation on a region and ending when the gaze is directed away from the region to the right. Thus, regression-path duration includes time spent rereading

earlier parts of the sentence before the reader is ready to proceed with the rest of the sentence. *Second-pass duration* is the time spent rereading a region after the eyes have exited the right boundary of this region. Unlike the other measures, second-pass duration includes zeroes (i.e., trials when the reader did not reread this region). *Total time* is the sum of all fixations on a word or region.

We report reading times for three regions of interest. The *verb region* was the main verb in the Simple-Sentence conditions and the embedded verb in the SRC conditions (e.g., *began* or *wrote*). The *target NP* consisted of the determiner and noun that followed the verb (e.g., *the memo*). The *postnoun region* consisted of the three words following the target NP in most cases (e.g., *about the new*). For four of our items, there were only two words that remained constant following the target NP between the Simple-Sentence and SRC conditions. For these four items, the postnoun region consisted of only those two words.

An automatic procedure in the Eyelink software combined fixations that were shorter than 80 ms and within one character of another fixation into one fixation. Additional fixations shorter than 80 ms and longer than 800 ms were removed. We set maximum cutoff values at 1,500 ms for gaze duration and second-pass duration and 2,500 ms for regression-path duration and total time. This procedure is similar to other data-exclusion procedures that have been employed in eye-tracking experiments on complement coercion (Frisson & McElree, 2008; McElree, Frisson, & Pickering, 2006; Traxler, McElree, et al., 2005). This procedure eliminated 0.3% of the data.

Results

Comprehension-question accuracy. Mean comprehension-question accuracies for each condition were as follows: Simple-Coercion (94%), Simple-Control (96%), SRC-Coercion (95%), SRC-Control (94%). There were no significant differences between conditions.

Verb region. Mean reading times for the three regions of interest are presented in Table 6. At the verb, significant main effects of sentence structure emerged in gaze duration, $F_1(1, 35) = 4.20$, $MSE = 2{,}029$, $p < .05$; $F_2(1, 35) = 4.02$, $MSE = 2{,}036$, $p = .05$, and in total time (marginal in the item analysis), $F_1(1, 35) = 7.45$, $MSE = 13{,}344$, $p < .02$; $F_2(1, 35) = 3.51$, $MSE = 25{,}400$, $p < .07$. For both measures, reading times were longer in the Simple-Sentence condition than the SRC condition, indicating that readers tended to spend more time processing the verb when it was the main verb of the sentence than when it was embedded in an SRC. In addition, strong main effects of verb type were observed in both second-pass duration, $F_1(1, 35) = 52.54$, $MSE = 9{,}329$, $p < .001$; $F_2(1, 35) = 28.64$, $MSE = 17{,}052$, $p < .001$, and in total time, $F_1(1, 35) = 55.45$, $MSE = 13{,}253$, $p < .001$; $F_2(1, 35) = 30.21$, $MSE = 26{,}202$, $p < .001$, with longer times in the Coercion condition than in the Control condition. The interaction between verb type and sentence structure was not significant on any measure.

Target NP. Analysis of all four reading-time measures on the target NP revealed main effects of verb type such that the Coercion condition was more difficult to process than the Control condition. The effect was marginally significant in gaze duration , $F_1(1, 35) = 3.85$, $MSE = 3{,}657$, $p < .06$; $F_2(1, 35) = 4.24$, $MSE = 3{,}654$, $p < .05$, but fully significant in regression-path duration, $F_1(1, 35) = 17.55$, $MSE = 5{,}503$, $p < .001$; $F_2(1, 35) = 8.62$, $MSE = 10{,}930$, $p < .01$, second-pass duration, $F_1(1, 35) = 9.90$, $MSE = 7{,}389$, $p < .005$; $F_2(1, 35) = 5.51$, $MSE = 12{,}843$, $p < .03$, and total time, $F_1(1, 35) = 14.40$, $MSE = 14{,}583$, $p < .005$; $F_2(1, 35) = 10.58$,

MSE = 19,866, $p < .005$. In addition, there was a marginally significant main effect of sentence structure in the total time data, $F_1(1, 35) = 3.41$, *MSE* = 17,447, $p < .08$; $F_2(1, 35) = 2.89$, *MSE* = 19,541, $p < .10$, such that there were longer reading times for the target NP in the Simple-Sentence condition compared to the SRC condition. The interaction between verb type and sentence structure was not significant on any measure.

Table 6
Results of Experiment 1.

Measure (in milliseconds)	Verb	Target NP	Postnoun region
Simple-Coercion	*began*	*the memo*	*about the new ...*
Simple-Control	*wrote*	*the memo*	*about the new ...*
SRC-Coercion (*that*)	*began*	*the memo*	*about the new ...*
SRC-Control (*that*)	*wrote*	*the memo*	*about the new ...*
Gaze duration			
Simple-Coercion	264	316	400
Simple-Control	255	286	406
SRC-Coercion	254	295	412
SRC-Control	234	286	414
Regression-path duration			
Simple-Coercion	342	445	534
Simple-Control	335	387	487
SRC-Coercion	329	409	577
SRC-Control	329	363	480
Second-pass duration			
Simple-Coercion	332	271	204
Simple-Control	218	227	203
SRC-Coercion	318	250	239
SRC-Control	198	205	232
Total time			
Simple-Coercion	647	634	674
Simple-Control	503	561	660
SRC-Coercion	593	597	747
SRC-Control	452	517	694

Note. NP = noun phrase; SRC = subject-extracted relative clause.

Postnoun region. Regression-path duration on the postnoun region showed a significant main effect of verb type, $F_1(1, 35) = 12.49$, $MSE = 14{,}833$, $p < .005$; $F_2(1, 35) = 9.65$, $MSE = 21{,}000$, $p < .005$, with longer times seen in the Coercion condition than the Control condition. In addition , there was a main effect of sentence structure that was marginal in the analysis of second-pass duration, $F_1(1, 35) = 3.20$, $MSE = 11{,}470$, $p < .09$; $F_2(1, 35) = 3.20$, $MSE = 9{,}973$, $p < .09$, and fully significant in the analysis of total time, $F_1(1, 35) = 7.38$, $MSE = 13{,}824$, $p < .02$; $F_2(1, 35) = 5.99$, $MSE = 17{,}124$, $p < .03$. These measures of later processing showed longer reading times on the postnoun region in the SRC condition compared to the Simple-Sentence condition, a pattern that reverses the effect found for the earlier target verb and target NP regions. Although the words in this three-word region were identical across all conditions, the subsequent words depended on sentence structure, and included the matrix verb for sentences in the SRC condition. Thus, this effect likely reflects the difficulty associated with processing the SRC matrix verb, with readers being more likely to go back and reread the preceding material in the SRC condition. The interaction between verb type and sentence structure was not significant on any measure.

Discussion

The results of Experiment 1 replicated previous reading-time studies in demonstrating the online costs associated with processing complement coercion (Frisson & McElree, 2008; McElree et al., 2001; McElree, Frisson, & Pickering, 2006; Pickering et al., 2005; Traxler, Pickering, & McElree, 2002; Traxler, McElree, et al., 2005). In line with these previous studies, the greater difficulty in processing coerced compared to control expressions emerged in regression-path duration on both the target NP and the postnoun region, as well as in second-pass duration and total time on both the verb and target NP. In addition, there was some evidence that

the difficulty with coercion emerged as early as gaze duration on the target NP; effects of coercion have occasionally been observed this early in the eye-tracking record (see Frisson & McElree), though it is not typical.

Critically, Experiment 1 showed no evidence that embedding the verb and complement NP in a relative clause reduced the magnitude of the coercion cost. Although readers did spend less time overall on critical words in the SRC condition compared to the same words in the Simple-Sentence condition (i.e., gaze duration and total time on the verb, as well as total time on the target NP), this effect did not depend on verb type. The finding that a coercion cost emerges when the critical words appear together in an RC is consistent with our previous work on inanimate subject-verb integration (Lowder & Gordon, 2012, Experiment 1) and suggests that the embedding manipulation does not influence the depth at which readers compute the relationship between the constituents in a complex semantic expression. In contrast, Lowder and Gordon's Experiment 2 showed that the difficulty associated with inanimate subject-verb integration was reduced when the two constituents appeared in separate clauses. Thus, we predicted that embedding the event-selecting verb and complement NP in separate clauses would deemphasize their relationship, which would result in a reduction in the magnitude of the coercion cost.

Experiment 2

Experiment 2 tested whether placing the critical constituents in separate clauses would reduce the coercion cost. As shown below (4a and 4b), the complement NP was positioned as the main clause subject and the head noun of an object-extracted relative clause (ORC) that contained the critical verb. The magnitude of the coercion cost in this configuration was

compared to that found for SRC sentences (4c and 4d) where both critical expressions were embedded in the relative clause.

4a. The memo that the secretary began announced that there would be pay raises for all the employees. (ORC, Coercion)

4b. The memo that the secretary wrote announced that there would be pay raises for all the employees. (ORC, Control)

4c. The secretary that began the memo announced that there would be pay raises for all the employees. (SRC, Coercion)

4d. The secretary that wrote the memo announced that there would be pay raises for all the employees. (SRC, Control)

In previous work, we showed that the magnitude of the processing difficulty associated with other complex semantic relationships is reduced when the structure of the sentence deemphasizes the noncanonical relationship (Lowder & Gordon, 2012, 2013). Specifically, we demonstrated that when the integration of an inanimate subject with an action verb occurred across a clause boundary (e.g., *The pistol that injured*), or when a metonym appeared in an adjunct phrase rather than as the object of the verb that elicited the figurative interpretation (e.g., *offended the honor of the college*), processing difficulty was reduced. In line with these previous findings, the cost of complement coercion should be reduced when integration of the verb and complement NP occurs across a clause boundary (e.g., *The memo that the secretary began*), such that the entity NP undergoes coercion as a filler at the post-verbal gap site. This reduction in the cost of coercion should occur because the structure of the sentence directs the reader's attention toward the proposition being asserted in the main clause of the sentence (e.g., *The memo announced that there would be pay raises*), whereas the additional proposition contained in the relative clause

(e.g., *The memo that the secretary wrote/began*) is seen as less important to comprehending the sentence. Because the relationship between the complement NP and verb is deemphasized by the ORC, we propose that readers will interpret this noncanonical relationship less deeply than when the relationship between the two constituents is focused, as is the case when the two constituents appear together in the same clause of an SRC (see General Discussion).

The current experiment also provides an opportunity to examine factors that influence the difficulty of processing ORC sentences as compared to SRC sentences, though its design presents some challenges for localizing the effect within the sentences. Whereas many previous experiments have examined differences in reading times on the RC region for ORCs versus SRCs (e.g., Gordon, Hendrick, Johnson, & Lee, 2006; Johnson, Lowder, & Gordon, 2011; Lowder & Gordon, 2012, in press; Traxler, Morris, & Seely, 2002; Traxler, Williams, Blozis, & Morris, 2005; see Gordon & Lowder, 2012 for a review), the ORCs in the current experiment always contained an embedded noun that was animate, whereas the embedded noun in the SRCs was almost always inanimate (e.g., *the secretary wrote* versus *wrote the memo*). This covariation of animacy with sentence structure renders comparison of the RC-region inappropriate. However, all four conditions are identical at the matrix verb (e.g., *announced*), which is another region of the sentence where ORC-SRC differences are typically observed (e.g., Gordon, Hendrick, & Johnson, 2001, 2004; Gordon et al., 2006; Johnson et al., 2011; King & Just, 1991; Lowder & Gordon, 2012, in press; Traxler et al., 2002, 2005; Wells, Christiansen, Race, Acheson, & MacDonald, 2009). Thus, the comparison of (4b) versus (4d) at the matrix verb allows us to test whether ORCs are more difficult than SRCs in the Control condition, whereas the comparison of (4a) versus (4c) at the matrix verb allows us to test whether the ORC-SRC asymmetry is reduced or eliminated in the case of complement coercion.

Method

Participants. Forty students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision. No participants had taken part in Experiment 1.

Materials. Each participant was presented with 36 experimental sentences and 90 filler sentences. The experimental sentences (see example 4) were adapted from the materials used in Experiment 1. The SRCs were identical to the SRCs used in Experiment 1 up to and including the target NP (e.g., *The secretary that began the memo*). The ORCs were created by positioning the target NP as the sentence subject and embedding the agent inside the RC along with the verb (e.g., *The memo that the secretary began*). The remainder of the sentence was rewritten to include a matrix verb and post-verb material that could be attributed to either the animate head NP in the SRCs or the inanimate head NP in the ORCs. See Appendix B for the full set of experimental stimuli.

Predictability. Twenty-four participants, none of whom participated in any other aspect of the study, were presented with initial fragments of the stimuli used in Experiment 2 and instructed to continue each fragment to make a complete sentence. The SRCs for both the Coercion and Control conditions were presented up to and including the determiner before the critical noun (e.g., *The secretary that began/wrote the*…), whereas the ORCs were presented up to the end of the embedded NP (e.g., *The memo that the secretary*…). Participants' responses were then compared with the actual experimental stimuli to assess the predictability of the critical words. Mean proportion of correct completions are presented in Table 7. There was a significant main effect of verb type, $F(1, 23) = 124.64$, $p < .001$, such that completions in the

Control condition were more accurate than completions in the Coercion condition. A similar effect was reported by Traxler, Pickering, and McElree (2002), whose stimuli were the basis of those used here; analyses by Traxler et al. suggested that this difference in predictability was unlikely to explain the processing costs reported in their experiments. The main effect of sentence structure was not significant; however, there was a significant interaction between verb type and sentence structure, $F(1, 23) = 28.87$, $p < .001$, with a larger discrepancy in correct completion rates between the Control and Coercion conditions for the ORCs than for the SRCs. Thus, the upcoming word in the Coercion condition was more predictable in SRCs than ORCs, a pattern of predictability that is the opposite of the predicted patterns for reading times.

Table 7
Predictability results from Experiment 2 completion study.

SRC-Coercion	*The secretary that began the* _____.
SRC-Control	*The secretary that wrote the* _____.
ORC	*The memo that the secretary* _____.

Predictability of target word		Categorization of completions	
Condition	Proportion correct	Condition	Event rating
SRC-Coercion	.08	SRC-Coercion	.33
SRC-Control	.25	SRC-Control	.05
ORC-Coercion	.00	ORC	.01
ORC-Control	.35		

Note. SRC = subject-extracted relative clause; ORC = object-extracted relative clause. Participants completed SRC fragments with a noun phrase (NP) and ORC fragments with a verb. "Predictability of target word" on the left displays the mean proportion of correct completions for each of the four conditions. "Categorization of completions" on the right displays the mean event rating for the two SRC conditions and for the single ORC condition (note that the ORC fragment was identical for the ORC-Coercion and ORC-Control conditions). For SRC fragments, a score of "0" represented an entity NP, whereas a score of "1" represented an event NP. For ORC fragments, a score of "0" represented an entity-selecting verb, whereas a score of "1" represented an event-selecting verb.

In addition, two independent raters, who were naïve to the purposes of the study, were presented with the NPs supplied in the completion of each SRC and assigned the code of "0" to

NPs referring to entities and "1" to NPs referring to events. Agreement between raters was 91%. Each verb provided for ORC fragments was also coded as "0" for entity-selecting and "1" for event-selecting. Table 7 shows mean event ratings for the two SRC conditions and for the ORCs. Mean scores were higher for the SRC-Coercion condition than the SRC-Control condition, $t(23) = 9.38$, $p < .001$, reflecting participants' greater tendency to provide event NP completions when the verb provided in the fragment was an event-selecting verb. In addition, mean scores for the SRC-Control condition were significantly higher than mean scores for the ORC condition, $t(23) = 2.35$, $p < .03$. This difference reflects the fact that participants were extremely unlikely to complete an ORC fragment with an event-selecting verb. Thus, any reduction in the magnitude of the coercion effect for ORCs compared to SRCs cannot be attributed to readers' being more likely to predict an event-selecting verb in the ORCs than an event NP in the SRCs.

Procedure. The sentences were counterbalanced across four lists, as in Experiment 1. All aspects of the eye-tracking procedure were identical to the procedure described in Experiment 1.

Analysis. The different word orders of the two types of RCs posed some challenges to analyzing these data. Experiment 1 showed coercion effects early in the sentence (i.e., gaze duration and regression-path duration at the target NP). However, for this experiment the earliest region of the sentence where a process of complement coercion could begin involved different words for SRCs and ORCs (i.e., the embedded NP in SRCs and the embedded verb in ORCs). Therefore, gaze duration and regression-path duration at this *initial coercion cue* were analyzed separately for the two types of RCs. At the matrix verb, the word orders of SRCs and ORCs are identical, and so the two structures were analyzed together relying on the same reading-time

measures used in Experiment 1. Second-pass duration on the target NP and embedded verb was defined as the time spent rereading after the eyes had gotten past the initial coercion cue during first-pass reading. For example, rereading of the target NP in the ORCs (e.g., *The memo*) was incorporated into second-pass duration if the reader had gotten past the embedded verb (e.g., *began*), and thus had encountered the cue to engage in coercion. As in Experiment 1, total time on the target NP and embedded verb were analyzed. The same data-exclusion criteria used in Experiment 1 were also employed here, eliminating 0.4% of the data.

Results

Comprehension-question accuracy. Mean comprehension-question accuracies for each condition were as follows: SRC-Coercion (96%), SRC-Control (93%), ORC-Coercion (92%), ORC-Control (92%). Accuracy tended to be higher for SRCs than for ORCs, although the main effect of sentence structure was significant only in the subject analysis, $F_1(1, 39) = 5.33$, $MSE = 52.21$, $p < .03$; $F_2(1, 35) = 1.29$, $MSE = 194.98$, $p > .25$. Neither the main effect of verb type nor the interaction between sentence structure and verb type was significant.

Initial coercion cue. Reading times are presented in Table 8. To determine whether there was any early evidence of processing difficulty associated with coercion, we analyzed gaze duration on the initial coercion cue (i.e., the target NP in the SRCs and the embedded verb in the ORCs). For SRCs, there was a marginally significant effect of coercion in the subject analysis, $t_1(39) = 1.79$, $p = .08$; $t_2(35) = 1.56$, $p > .12$. There was no evidence of a coercion cost in gaze duration on the embedded verb for the ORCs, ts < 1. Analysis of regression-path duration on the

initial coercion cue revealed a significant effect of coercion for the SRCs, $t_1(39) = 2.24$, $p < .05$; $t_2(35) = 2.67$, $p < .02$, but no indication of a difference for the ORCs, ts < 1.[8]

Matrix verb. The Coercion condition was more difficult than the Control condition at the matrix verb. These significant main effects of verb type emerged in analysis of regression-path duration, $F_1(1, 39) = 16.27$, $MSE = 34{,}887$, $p < .001$; $F_2(1, 35) = 33.41$, $MSE = 15{,}785$, $p < .001$, second-pass duration, $F_1(1, 39) = 18.25$, $MSE = 7{,}298$, $p < .001$; $F_2(1, 35) = 12.23$, $MSE = 10{,}063$, $p < .005$, and total time, $F_1(1, 39) = 27.19$, $MSE = 16{,}039$, $p < .001$; $F_2(1, 35) = 18.72$, $MSE = 22{,}986$, $p < .001$. In addition, regression-path duration on the matrix verb showed a main effect of sentence structure (in the subject analysis), $F_1(1, 39) = 7.03$, $MSE = 13{,}888$, $p < .02$; $F_2(1, 35) = 2.46$, $MSE = 24{,}459$, $p > .12$, such that times were longer in ORCs than SRCs. Critically, analysis of regression-path duration showed a significant interaction between these two factors, $F_1(1, 39) = 7.76$, $MSE = 12{,}668$, $p < .01$; $F_2(1, 35) = 5.15$, $MSE = 21{,}675$, $p < .05$. Follow-up contrasts revealed that whereas there was a robust coercion effect in the SRCs (169 ms), $t_1(39) = 4.68$, $p < .001$; $t_2(35) = 5.68$, $p < .001$, the effect was much weaker in the ORCs (70 ms), and only reached significance in the subject analysis, $t_1(39) = 2.12$, $p < .05$; $t_2(35) = 1.96$, $p < .06$. In addition, whereas the Control conditions showed a typical ORC-SRC asymmetry, with

[8] We also tested for differences in gaze duration and regression-path duration in the reverse contrasts (i.e., the target NP in ORCs and the embedded verb in SRCs). As would be expected, gaze durations on the target NP did not differ between the Coercion and Control conditions in the ORCs, ts < 1. Because this region came at the very beginning of the sentence in the ORCs, analysis of regression-path duration is not appropriate. There was a significant difference in gaze duration on the embedded verb in the SRCs (marginal in the item analysis), $t_1(39) = 2.14$, $p < .05$; $t_2(35) = 1.98$, $p < .07$, such that reading times were longer on the Coercion verbs than the Control verbs. This difference was not expected, given that the target NP had not yet been fixated and given that we used the exact same verbs in Experiment 1 and found no evidence of a difference in gaze duration. However, as noted above, the verbs in the Coercion condition were on average longer than the verbs in the Control condition (see Experiment 1 Methods), and it is well-known that increases in word length tend to inflate gaze duration (e.g., Rayner, 1998; Rayner & McConkie, 1976; Rayner, Sereno, & Raney, 1996). The notion that this difference in gaze duration reflects differences in verb length rather than differences related to complement coercion is bolstered by the fact that regression-path duration did not differ between these two conditions, ts < 1.

ORCs being more difficult than SRCs, $t_1(39) = 4.56$, $p < .001$; $t_2(35) = 3.37$, $p < .005$, the ORC-Coercion and SRC-Coercion conditions were identical to one another.

Table 8
Results of Experiment 2.

SRC-Coercion	*The secretary that began the memo announced …*
SRC-Control	*The secretary that wrote the memo announced …*
ORC-Coercion	*The memo that the secretary began announced …*
ORC-Control	*The memo that the secretary wrote announced …*

Measure (in milliseconds)	Embedded verb (e.g., *began* vs. *wrote*)	Target NP (e.g., *the memo*)	Matrix verb (e.g., *announced*)
Gaze duration			
SRC-Coercion	271	348	324
SRC-Control	251	327	314
ORC-Coercion	284	441	333
ORC-Control	276	446	339
Regression-path duration			
SRC-Coercion	348	456	539
SRC-Control	335	400	370
ORC-Coercion	363	—	539
ORC-Control	353	—	469
Second-pass duration			
SRC-Coercion	300	297	214
SRC-Control	181	190	146
ORC-Coercion	277	274	189
ORC-Control	141	222	141
Total time			
SRC-Coercion	644	712	626
SRC-Control	472	575	499
ORC-Coercion	581	772	605
ORC-Control	438	739	523

Note. NP = noun phrase, SRC = subject relative clause, ORC = object relative clause

Embedded verb. Measures of later processing revealed robust coercion costs on the embedded verb. These main effects of verb type were seen in second-pass duration, $F_1(1, 39) = 82.75$, $MSE = 7{,}802$, $p < .001$; $F_2(1, 35) = 38.51$, $MSE = 14{,}631$, $p < .001$, as well as in total

time, $F_1(1, 39) = 61.33$, $MSE = 16{,}211$, $p < .001$; $F_2(1, 35) = 30.94$, $MSE = 28{,}913$, $p < .001$. In addition, these measures revealed main effects of sentence structure such that reading times were longer for SRCs than for ORCs. These effects were marginally significant in second-pass duration, $F_1(1, 39) = 4.06$, $MSE = 9{,}828$, $p < .06$; $F_2(1, 35) = 4.01$, $MSE = 9{,}428$, $p < .06$, and fully significant in total time, $F_1(1, 39) = 4.13$, $MSE = 23{,}259$, $p < .05$; $F_2(1, 35) = 5.75$, $MSE = 17{,}052$, $p < .05$. Although the interaction between sentence structure and verb type was not significant, the reversal observed for the ORC-SRC asymmetry can be explained by examining the contrasts separately for the Coercion and Control conditions. Total time on the embedded verb was significantly longer for the SRC-Coercion condition than the ORC-Coercion condition, $t_1(39) = 2.06$, $p < .05$; $t_2(35) = 2.33$, $p < .05$; however, there was no difference between the SRC-Control and ORC-Control conditions, $t_1(39) = 1.35$, $p > .18$; $t_2(35) = 1.36$, $p > .18$. Thus, it seems that the reversal in the ORC-SRC asymmetry was driven primarily by readers' enhanced difficulty processing the coerced expressions in the SRCs relative to the ORCs.

Target NP. Measures of later processing also revealed coercion costs on the target NP. These main effects of verb type were significant for second-pass duration, $F_1(1, 39) = 20.56$, $MSE = 12{,}242$, $p < .001$; $F_2(1, 35) = 30.25$, $MSE = 7{,}248$, $p < .001$, as well as for total time, $F_1(1, 39) = 13.87$, $MSE = 20{,}606$, $p < .005$; $F_2(1, 35) = 13.40$, $MSE = 17{,}682$, $p < .005$. In addition, there was a main effect of sentence structure for total time, $F_1(1, 39) = 11.95$, $MSE = 41{,}999$, $p < .005$; $F_2(1, 35) = 27.06$, $MSE = 15{,}680$, $p < .001$, such that ORCs were more difficult than SRCs. Critically, these two factors interacted. Analysis of second-pass duration revealed a marginally significant interaction between verb type and sentence structure, $F_1(1, 39) = 3.66$, $MSE = 8{,}514$, $p < .07$; $F_2(1, 35) = 2.48$, $MSE = 10{,}782$, $p > .12$, with the coercion cost for the SRCs (107 ms), $t_1(39) = 4.14$, $p < .001$; $t_2(35) = 4.08$, $p < .001$, being over twice as large as the coercion cost for

the ORCs (52 ms), $t_1(39) = 2.68$, $p < .02$; $t_2(35) = 2.77$, $p < .01$. The interaction was fully significant in total time, $F_1(1, 39) = 8.21$, $MSE = 13{,}334$, $p < .01$; $F_2(1, 35) = 5.86$, $MSE = 16{,}788$, $p < .03$. Follow-up contrasts revealed a robust coercion effect for the SRCs, $t_1(39) = 4.23$, $p < .001$; $t_2(35) = 3.97$, $p < .001$, with no effect at all for the ORCs, $t_1(39) = 1.26$, $p > .21$; $t_2(35) = 1.03$, $p > .30$. In addition, ORCs were more difficult than SRCs in the Control condition, $t_1(39) = 4.08$, $p < .001$; $t_2(35) = 6.31$, $p < .01$, whereas this difference was only marginally significant in the Coercion condition, $t_1(39) = 1.77$, $p < .09$; $t_2(35) = 1.66$, $p > .10$.

Discussion

Experiment 2 demonstrated that the processing cost associated with complement coercion is reduced when the verb and complement NP appear in separate clauses. The results of the predictability study (see Methods section) make it unlikely that this reduction was driven by expectations about the sentences, since completions of ORC fragments (e.g., *The memo that the secretary*…) very rarely included an event-selecting verb and never included the event-selecting verb that was actually used in the stimuli. Sentence structure led to a reduction in the processing cost of coercion as early as regression-path duration on the first region of the sentence that signaled the need to engage in coercion. Whereas the Coercion condition was more difficult than the Control condition at the target NP in SRCs, there was no difference at the embedded verb for the ORCs. This difference in processing difficulty carried over onto the matrix verb. Regression-path duration on this region showed a coercion effect that was more than twice as large in the SRCs than in the ORCs. The coercion cost was also larger for SRCs than for ORCs in second-pass duration on the target NP, and analysis of total time on the target NP showed a strong coercion cost for the SRCs and no evidence of a coercion cost at all for the ORCs.

Coercion costs also emerged in later processing measures on both the embedded verb and the matrix verb. These effects did not interact with sentence structure.

There was greater difficulty at the matrix verb for ORCs than for SRCs in the Control condition—an effect that has been documented by several previous eye-tracking studies (Gordon et al., 2006; Johnson et al., 2011; Lowder & Gordon, 2012, in press; Traxler, Morris, & Seely, 2002; Traxler, Williams, et al., 2005). This difference was eliminated completely in the Coercion condition due to the substantial processing difficulty associated with the SRC-Coercion condition. This pattern provides a nice parallel to the findings on structural separation and inanimate subject-verb integration reported by Lowder and Gordon (2012), in which we argued that the effects of animacy on RC processing that had been documented previously (Gennari & MacDonald, 2008, 2009; Traxler et al., 2002, 2005) could be explained by patterns of enhanced difficulty when integration occurs within the same clause, as in ORCs (e.g., *The sheriff that the pistol injured*), and reduced difficulty when integration occurs across a clause boundary, as in SRCs (e.g., *The pistol that injured the cowboy*). The current experiment produced similar findings with regard to complement coercion, although in this case the structural separation contributes to enhanced difficulty with SRCs (e.g., *The secretary that began the memo*) and reduced difficulty with ORCs (e.g., *The memo that the secretary began*).

Interpretation of these results is complicated by the differences in word order that exist between SRCs and ORCs. Whereas the critical words of the SRC appear in the same order as they do in a simple sentence (i.e., agent NP, verb, target NP), the structure of the ORC places the target NP at the beginning of the sentence (i.e., target NP, agent NP, verb). Thus, it may not be the structural separation between the verb and target NP that contributes to the reduction in processing difficulty, but rather the order in which the constituents appear. To address this

concern, we conducted Experiment 3, which manipulates the presence or absence of a structural separation between the verb and complement NP but also keeps the order of the content words constant across conditions.

Experiment 3

Experiment 3 further tested the hypothesis that the coercion cost would be reduced when the verb and complement NP appeared in separate clauses. Whereas Experiment 2 did this using different types of relative clauses, Experiment 3 uses different types of cleft constructions (see example 5). The clause structure of the clefts in (5a) and (5b) resembles that of the SRCs used in Experiments 1 and 2. That is, integration of the critical verb-NP pair occurs within the same clause. In contrast, the clause structure of the pseudoclefts in (5c) and (5d) imposes a boundary between the verb and complement NP, as was the case with the ORCs in Experiment 2. Importantly, the order of the content words is the same across the two types of clefts.

5a. It was the secretary that began the memo about the new office policy shortly after being hired. (Cleft, Coercion)

5b. It was the secretary that wrote the memo about the new office policy shortly after being hired. (Cleft, Control)

5c. What the secretary began was the memo about the new office policy shortly after being hired. (Pseudocleft, Coercion)

5d. What the secretary wrote was the memo about the new office policy shortly after being hired. (Pseudocleft, Control)

Cleft structures such as those in (5) have been used previously to examine the processing of linguistic information that is focused versus that which is nonfocused. The clefts in (5a) and (5b) place linguistic focus on *the secretary*, as they seem to answer the implied question, *Who*

wrote the memo? In contrast, the pseudoclefts in (5c) and (5d) place linguistic focus on *the memo*, as they seem to answer the implied question, *What did the secretary write?* As such, the structure of these sentences signals to the reader that some new piece of information is being asserted in contrast to information that is presented as presupposed. Previous work using structures like these as focus cues has shown that focused linguistic information enjoys a variety of processing benefits. For example, compared to nonfocused information, focused information attracts attention more quickly and more effectively (Carpenter & Just, 1977; Hornby, 1974; Langford & Holmes, 1979; Sturt, Sanford, Stewart, & Dawydiak, 2004; Zimmer & Engelkamp, 1981), is remembered better (Birch, Albrecht, & Myers, 2000; Birch & Garnsey, 1995; Singer, 1976), better facilitates anaphor resolution (Almor, 1999; Foraker & McElree, 2007), and leads to enhanced detection of false information (Bredart & Modolo, 1988). In addition, readers tend to spend more time processing focused compared to nonfocused information (Birch & Rayner, 1997; Price & Sanford, 2012, cf. Birch & Rayner, 2010). Thus, the complement NP should attract more attention and show longer processing times when it appears in a pseudocleft as compared to a cleft. However, pseudoclefts also impose a structural separation between the complement NP and the critical verb thereby dissociating the effects of focus on the complement and the effects of structural separation on the complex semantic processing that occurs with coercion. On the one hand, if the strong linguistic focus placed on the complement NP by the pseudocleft leads to enhanced relational processing, such that the reader engages in deep interpretation of the verb-complement relationship, then a larger coercion effect should occur for pseudoclefts compared to clefts. On the other hand, if the separation of the verb and complement NP into different clauses serves to deemphasize their relationship, then a smaller coercion effect should occur for pseudoclefts compared to clefts.

Whereas Experiment 1 showed that deemphasis of both constituents had no effect on the magnitude of the coercion cost, the design of the current experiment allows us to determine whether effects of sentence structure on the magnitude of the coercion cost stem from structural emphasis or deemphasis of the complement NP or on structural separation between the critical verb-complement pair.

Method

Participants. Forty-eight students at the University of North Carolina at Chapel Hill participated in this experiment in exchange for course credit. They were all native English speakers and had normal or corrected-to-normal vision. No participants had taken part in Experiments 1 or 2.

Materials. Each participant was presented with 36 experimental sentences and 110 filler sentences. The experimental sentences (see example 5) were adapted from the materials used in Experiments 1 and 2. The same agent NPs (e.g., *the secretary*), verbs (e.g., *wrote* versus *began*), and target NPs (e.g., *the memo*) that had been used in the previous experiments were also used here. These words were inserted into cleft and pseudocleft structures, and the post-target material was rewritten to form a coherent sentence. See Appendix C for the full set of experimental stimuli.

Predictability. Twenty-four participants, none of whom participated in any other aspect of the study, were presented with fragments of the stimuli used in Experiment 3 and instructed to continue each fragment to make a complete sentence. Fragments for all four conditions were presented up to and including the determiner before the critical noun (e.g., *It was the secretary that wrote/began the*…; *What the secretary wrote/began was the*…). Participants' responses were then compared with the actual experimental stimuli to assess the predictability of the

critical words. Mean proportion of correct completions are presented in Table 9. There was a significant main effect of verb type, $F(1, 24) = 39.09$, $p < .001$, such that completions in the Control condition were more accurate than completions in the Coercion condition. Neither the main effect of sentence structure nor the interaction between verb type and sentence structure was significant (Fs < 1.05, ps > .30).

As in Experiment 2, two independent raters coded the event status of the NPs supplied in the completions (entity NPs were coded as "0," and event NPs were coded as "1"). Agreement between raters was 90%. Table 9 shows mean event ratings for the four conditions. There was a significant main effect of verb type, $F(1, 24) = 118.05$, $p < .001$, indicating participants' greater tendency to provide entity NPs for the Control fragments and event NPs for the Coercion fragments. Neither the main effect of sentence structure nor the interaction between verb type and sentence structure was significant (Fs < 1.22, ps > .28) indicating that any effects of sentence structure on the magnitude of the coercion cost are unlikely to be due to readers' expectations about the stimulus sentences.

Table 9
Predictability results from Experiment 3 completion study.

Cleft-Coercion	*It was the secretary that began the* _____.	
Cleft-Control	*It was the secretary that wrote the* _____.	
Pseudocleft-Coercion	*What the secretary began was the* _____.	
Pseudocleft-Control	*What the secretary wrote was the* _____.	
	Proportion correct	Event rating
Cleft-Coercion	.05	.43
Cleft-Control	.25	.05
Pseudocleft-Coercion	.05	.36
Pseudocleft-Control	.22	.05

Note. For the event ratings, a score of "0" was assigned to entity NPs, whereas a score of "1" was assigned to event NPs.

Procedure. The sentences were counterbalanced across four lists, as in Experiments 1 and 2. All aspects of the eye-tracking procedure were identical to the procedure described in Experiment 1.

Analysis. One of the items contained an animate target NP (i.e., *The lawyer defended/endured the defendant*), that could not be readily adapted to the pseudocleft structure used for the rest of the items. This was addressed by constructing a different type of pseudocleft (i.e., *The one who the lawyer defended/endured was the defendant*). However, this item elicited extreme processing difficulty relative to the other pseudoclefts and was excluded from all analyses. Three regions of interest were defined as described in Experiment 1. For each of these regions, we analyzed gaze duration, regression-path duration, second-pass duration, and total time. The same data-exclusion criteria used in Experiments 1 and 2 were also employed here, eliminating 0.3% of the data.

Results

Comprehension-question accuracy. Mean comprehension-question accuracies for each condition were as follows: Cleft-Coercion (95%), Cleft-Control (95%), Pseudocleft-Coercion (96%), Pseudocleft-Control (95%). There were no significant differences between conditions.

Verb region. Mean reading times for the three regions of interest are presented in Table 10. Analysis of regression-path duration showed a significant main effect of sentence structure, such that times were longer for the Pseudocleft compared to the Cleft conditions, $F_1(1, 47) = 14.40$, $MSE = 7{,}295$, $p < .001$; $F_2(1, 34) = 10.01$, $MSE = 6{,}344$, $p < .005$. The verb in the Cleft condition immediately follows the complementizer *that*, which serves as a cue to the reader that the following information is less important relative to the focused information at the beginning of the sentence. Later processing measures also showed significant main effects of sentence

Table 10
Results of Experiment 3.

Measure (in milliseconds)	Verb		Target NP	Postnoun region	
Cleft-Coercion	*began*		*the memo*	*about the new*	...
Cleft-Control	*wrote*		*the memo*	*about the new*	...
Pseudocleft-Coercion	*began*	(*was*)	*the memo*	*about the new*	...
Pseudocleft-Control	*wrote*	(*was*)	*the memo*	*about the new*	...
Gaze duration					
Cleft-Coercion	257		321	431	
Cleft-Control	240		313	432	
Pseudocleft-Coercion	242		310	423	
Pseudocleft-Control	249		314	436	
Regression-path duration					
Cleft-Coercion	322		409	630	
Cleft-Control	309		366	483	
Pseudocleft-Coercion	366		502	614	
Pseudocleft-Control	359		472	547	
Second-pass duration					
Cleft-Coercion	238		225	186	
Cleft-Control	146		140	152	
Pseudocleft-Coercion	291		211	176	
Pseudocleft-Control	190		184	165	
Total time					
Cleft-Coercion	503		579	693	
Cleft-Control	398		478	615	
Pseudocleft-Coercion	583		586	681	
Pseudocleft-Control	473		555	659	

Note. NP = noun phrase.

structure in second-pass duration, $F_1(1, 47) = 12.29$, $MSE = 8{,}952$, $p < .005$; $F_2(1, 34) = 11.35$, $MSE = 7{,}825$, $p < .005$, and total time, $F_1(1, 47) = 17.80$, $MSE = 16{,}121$, $p < .001$; $F_2(1, 34) = 13.76$, $MSE = 12{,}850$, $p < .005$, such that times were longer in the Pseudocleft compared to the Cleft conditions. However, this effect is likely due to more rereading of the verb after hitting the target NP in the Pseudocleft condition (see below). In addition, there were robust coercion costs on this region, with main effects of verb type emerging in second-pass duration, $F_1(1, 47) =$

60.27, *MSE* = 7,370, $p < .001$; $F_2(1, 34) = 25.39$, *MSE* = 12,322, $p < .001$, and total time, $F_1(1, 47) = 41.04$, *MSE* = 13,340, $p < .001$; $F_2(1, 34) = 18.16$, *MSE* = 21,525, $p < .001$. The interaction between sentence structure and verb type was not significant on any measure.

Target NP. Readers spent more time processing the target NP when it was focused by virtue of being in a pseudocleft compared to when it was in a cleft. This main effect of sentence structure was observed in regression-path duration, $F_1(1, 47) = 31.23$, *MSE* = 15,276, $p < .001$; $F_2(1, 34) = 44.74$, *MSE* = 7,898, $p < .001$, and total time, $F_1(1, 47) = 5.39$, *MSE* = 15,879, $p < .03$; $F_2(1, 34) = 7.37$, *MSE* = 10,069, $p < .02$. In addition, there was a significant main effect of verb type in regression-path duration (marginal in the item analysis), $F_1(1, 47) = 7.78$, *MSE* = 13,055, $p < .05$; $F_2(1, 34) = 2.80$, *MSE* = 17,755, $p = .10$, second-pass duration, $F_1(1, 47) = 31.03$, *MSE* = 4,852, $p < .001$; $F_2(1, 34) = 6.33$, *MSE* = 16,600, $p < .02$, and total time, $F_1(1, 47) = 16.95$, *MSE* = 12,385, $p < .001$; $F_2(1, 34) = 3.89$, *MSE* = 33,464, $p < .06$, such that the Coercion condition was more difficult than the Control condition.

For regression-path duration, the interaction between sentence structure and verb type was not significant, though planned contrasts indicated a coercion effect for the Cleft condition, $t_1(47) = 2.26$, $p < .03$; $t_2(34) = 1.94$, $p = .06$, but not for the Pseudocleft condition, $t_1(47) = 1.15$, $p > .25$; $t_2(34) < 1$. For second-pass duration, the interaction between sentence structure and verb type was significant, $F_1(1, 47) = 5.81$, *MSE* = 6,881, $p < .03$; $F_2(1, 34) = 3.97$, *MSE* = 6,733, $p = .05$. Planned contrasts showed a strong coercion effect for the Cleft condition, $t_1(47) = 5.26$, $p < .001$; $t_2(34) = 3.29$, $p < .005$, whereas the coercion effect for the Pseudocleft condition did not reach significance, $t_1(47) = 1.80$, $p > .07$; $t_2(34) = 1.02$, $p > .31$. In addition, there was a significant effect of sentence structure for the Control condition, such that the Pseudocleft-Control condition was more difficult than the Cleft-Control condition, $t_1(47) = 2.97$, $p < .01$;

$t_2(34) = 2.28$, $p < .05$, but there was no difference between the Pseudocleft-Coercion condition and the Cleft-Coercion condition, ts < 1. For total time, the interaction between sentence structure and verb type was again significant, $F_1(1, 47) = 4.91$, $MSE = 11{,}892$, $p < .05$; $F_2(1, 34) = 3.72$, $MSE = 11{,}434$, $p = .06$. Whereas there was a strong coercion effect for the Cleft condition, $t_1(47) = 4.56$, $p < .001$; $t_2(34) = 2.96$, $p < .01$, the effect was eliminated altogether in the Pseudocleft condition, $t_1(47) = 1.37$, $p > .17$; $t_2(34) < 1$. In addition, there was a significant effect of sentence structure for the Control condition, such that the Pseudocleft-Control condition was more difficult than the Cleft-Control condition, $t_1(47) = 3.16$, $p < .005$; $t_2(34) = 3.60$, $p < .005$, but there was no difference between the Pseudocleft-Coercion condition and the Cleft-Coercion condition, ts < 1.

Postnoun region. There were no significant main effects of sentence structure in the postnoun region. In contrast, main effects of verb type emerged in analysis of regression-path duration, $F_1(1, 47) = 34.28$, $MSE = 16{,}117$, $p < .001$; $F_2(1, 34) = 11.59$, $MSE = 32{,}592$, $p < .005$, and total time (significant in the subject analysis), $F_1(1, 47) = 5.71$, $MSE = 20{,}731$, $p < .03$; $F_2(1, 34) = 1.81$, $MSE = 39{,}581$, $p > .18$. For regression-path duration, the interaction between sentence structure and verb type was significant, $F_1(1, 47) = 4.90$, $MSE = 15{,}600$, $p < .04$; $F_2(1, 34) = 5.71$, $MSE = 9{,}757$, $p < .03$, with the coercion effect for the Cleft condition (147 ms), $t_1(47) = 5.89$, $p < .001$; $t_2(34) = 3.88$, $p < .001$ being over twice as large as the coercion effect for the Pseudocleft condition (67 ms), $t_1(47) = 2.55$, $p < .02$; $t_2(34) = 1.98$, $p < .06$. In addition, there was a significant effect of sentence structure for the Control condition, such that the Pseudocleft-Control condition was more difficult than the Cleft-Control condition, $t_1(47) = 2.84$, $p < .01$; $t_2(34) = 2.71$, $p < .02$, but that there was no difference between the Pseudocleft-Coercion condition and the Cleft-Coercion condition, ts < 1. For total time, the interaction between

sentence structure and verb type was marginally significant, $F_1(1, 47) = 2.91$, $MSE = 13{,}037$, $p < .10$; $F_2(1, 34) = 2.31$, $MSE = 12{,}271$, $p > .13$. Planned contrasts showed evidence of a coercion effect for the Cleft condition, $t_1(47) = 3.21$, $p < .005$; $t_2(34) = 1.97$, $p < .06$, and no difference between the Pseudocleft-Coercion and Pseudocleft-Control conditions, ts < 1.

Discussion

In line with the results of Experiment 2, Experiment 3 demonstrated that the processing cost associated with complement coercion is reduced when the verb and complement NP appear in separate clauses. Evidence for this reduction in difficulty was seen at the complement NP in measures of regression-path duration, second-pass duration, and total time, and also on the postnoun region in measures of regression-path duration and total time. A similar reduction in coercion cost was observed in Experiment 2, but differences in word order between those SRCs and ORCs made it difficult to determine whether the reduction was due to structural separation or to some other factor associated with the different word orders. In contrast, the cleft and pseudocleft structures in the current experiment presented the content words in the same order, which reinforces the notion that these patterns of effects are due to differences in emphasis on the relationship between the verb and complement NP that structural separation affords. When the verb and complement NP appeared together in the same clause (e.g., *It was the secretary that began the memo…*), robust coercion costs were observed across several regions of the sentence but this effect was reduced substantially when the verb and complement NP appeared in separate clauses (e.g., *What the secretary began was the memo…*).

The results of this experiment also demonstrate that while the amount of processing on the complement NP is increased by linguistic focus, linguistic focus does not increase the cost of coercion. This finding shows that the difficulty of understanding complex semantic expressions

is due to noncanonical relationships among multiple elements in the sentence, with sentence structure guiding the reader's limited attention to some relationships but not others. When a complex semantic relationship is particularly salient, by virtue of all its components appearing together in a single clause, readers are more likely to focus on the relationship among these words and engage in a process of deep interpretation. When instead the various elements that constitute a complex expression appear in separate clauses, the relationship is seen as being less important to the overall interpretation of the sentence, leading to shallower processing that does not fully address the semantic mismatch that is the source of the complexity.

General Discussion

Taken together, the three experiments reported in this paper demonstrated that the processing cost associated with complement coercion was reduced when the event-selecting verb and entity NP appeared in different clauses. Experiment 1 compared the magnitude of the coercion cost in a simple-sentence context (e.g., *The secretary began the memo*) to a sentence context where the critical verb and complement appeared together inside an RC (e.g., *The secretary that began the memo*). Readers spent less time on the critical words when they were in an RC compared to when they were in the main clause; however the magnitude of the coercion cost was unaffected, suggesting that readers still computed the complex relationship between these constituents when both of them were deemphasized. In contrast, when the complement NP appeared as the main-clause head and the event-selecting verb was embedded in an RC in Experiment 2 (e.g., *The memo that the secretary began*), difficulty was reduced relative to when both constituents appeared together inside the RC (e.g., *The secretary that began the memo*). Finally, the cleft and pseudocleft structures used in Experiment 3 allowed for a direct test of whether placing linguistic focus on the complement NP (i.e., the element that needs to be type-

shifted) leads to enhanced processing difficulty or whether structural separation of the verb and complement leads to reduced difficulty. Readers spent more time processing the complement NP when it was focused by the pseudocleft (e.g., *What the secretary wrote/began was the memo*) compared to when the cleft focused a different NP (e.g., *It was the secretary that wrote/began the memo*), suggesting that the structural properties of the pseudocleft did draw readers' attention to the complement. However, the magnitude of the coercion cost was reduced when the verb and complement appeared in separate clauses in the pseudoclefts compared to when they appeared in the same clause in the clefts. This pattern of effects may seem counterintuitive. That is, given that the pseudocleft highlights the complement as the most important element of the sentence, one might expect that this would also cause the reader to relate it to the other elements of the sentence in a deep and meaningful way, which would result in a larger coercion cost for the pseudoclefts than the clefts. The fact that the opposite pattern of effects was obtained, combined with the finding from Experiment 1 that deemphasis of both constituents had no effect on the coercion cost, underscores the importance of considering how sentence structure influences the *relationships* between various constituents in the sentence and how emphasis or deemphasis of a single element may change its relation to other elements in the sentence.

The processing cost of coercion has been explained as arising from detection of a mismatch between the semantic characteristics of the verb and complement that then triggers an effortful process of reconfiguring the entity interpretation into an event interpretation (Traxler, McElree, et al., 2005). In other words, a straightforward combination of the literal meanings of the verb and complement results in a defective interpretation, which requires the comprehender to derive a more appropriate meaning of the expression (Searle, 1979). Accounts of the coercion cost have not typically been considered alongside accounts of figurative language processing and

other types of complex semantic expressions; however, we propose that they are similar in the sense that they involve a semantic mismatch and require greater processing as compared to more literal control expressions. The findings reported here and in our previous work (Lowder & Gordon, 2012, 2013) support a basic prediction of the indirect access model for determining the meaning of complex semantic relations in sentences where there is a close structural relationship between the overt expressions that convey the mismatched meanings. In particular, processing time on the critical expressions was longer for complex semantic relations than for a variety of control conditions. Differences in time to comprehend complex versus control meanings have been commonly used in tests of the indirect access model (e.g., Clark & Lucy, 1975; Gerrig & Healy, 1983; Gildea & Glucksberg, 1983; Glucksberg, Gildea, & Bookin, 1982; Frisson & Pickering, 1999; Inhoff, Lima, & Carroll, 1984; Janus & Bever, 1985; Keysar, 1989; Ortony, Schallert, Reynolds, & Antos, 1978; Shinjo & Myers, 1987; for reviews, see Glucksberg, 2001, 2003). According to the indirect access model, the difference in reading times is due to the time necessary to detect the semantic mismatch and to undertake the additional processing required for meaningful interpretation. We propose that the need to detect and resolve the semantic mismatch is common across different types of complex semantic relations but that the mechanisms for detection and resolution of the semantic mismatch are likely to differ depending on the type of expression. For example, it has been argued that the cost of complement coercion reflects the time needed to mentally construct semantic representations that are not explicitly licensed by the syntax of the sentence (e.g., Frisson & McElree, 2008; Traxler et al., 2002, 2005). In contrast, it could be argued that for familiar metonyms resolution of the mismatch reflects operations involved in selecting the figurative sense of the word after initial consideration of its non-metonymic sense—a process that would be similar to finding the

contextually appropriate meaning of a homonym (e.g., Duffy, Morris, & Rayner, 1988; Rayner & Duffy, 1986; Rayner & Frazier, 1989; Sereno, Pacht, & Rayner, 1992). The greater magnitude and broader distribution of the coercion cost as compared to the metonymy cost (see Lowder & Gordon, 2013) support the idea of a difference in the interpretation of complement coercion and metonymy. This view is consistent with the interpretation offered by McElree, Frisson, & Pickering (2006) that "…there is a straightforward process of accessing a familiar metonym, but…a more complex process of enriched composition is involved in the resolution of [coercion]" (p. 189) in conceptualizing interpretation of complement coercion as more complex than interpretation of familiar metonyms. However, our characterization differs from that of McElree et al. in that interpreting a familiar metonym is not regarded as completely straightforward (see Lowder & Gordon, 2013, for a discussion).

Our findings further show that the difference in time spent processing complex semantic relations as compared to control conditions is eliminated or reduced when there is a distant structural relationship between the overt expressions that convey the mismatched meanings. The indirect access model does not predict this moderating effect of sentence structure but it identifies two stages of processing where it might occur. When the overt expressions that convey the mismatched meanings are structurally separated readers might be less likely to detect a semantic mismatch or they might interpret semantic relationships at a shallow level which does not lead to the extra processing required for full understanding. This perspective highlights the importance of sentence structure as a powerful cue to language comprehension—one that indicates not only that particular constituents should be processed more deeply than others but also that particular relationships should be processed more deeply than others. We propose that

there are several underlying mechanisms that may further explain the moderating effect of sentence structure.

One possibility is that when an expression (e.g., a verb and complement) must be integrated across a clause boundary, readers compute the syntactic relationship between these two constituents but leave the semantic relationship underspecified. Traditional notions of sentence processing propose that the meaning of a sentence is composed through a straightforward process that involves computing syntactic relationships among the words in the sentence and then using corresponding semantic operations to methodically assemble individual word meanings into an overall sentence meaning. Complement coercion, as an example of enriched composition, challenges standard views of sentence processing by showing that language conveys meanings derived from the relation between expressions that are not explicitly licensed by syntax (see Pylkkänen & McElree, 2006, for a discussion). When expressions requiring complement coercion are embedded in a syntactically complex sentence, readers may be particularly concerned with gaining a basic understanding of how the various nouns and verbs combine structurally and may not be as concerned with deriving a complete interpretation of the meaning of the relation between expressions. For example, given a sentence like *The memo that the secretary began announced …*, readers may process the relations between the main clause and relative clause at a level where they understand that the secretary had something to do with the memo, but they do not fully distinguish the relationship until a later processing stage or perhaps not at all (for further discussion of underspecification, see Frisson, 2009; Frisson & Pickering, 1999, 2001; Lowder & Gordon, 2013). This perspective is similar to the notion of good-enough processing (Ferreira et al., 2002; Ferreira & Patson, 2007), which proposes that

comprehenders often fail to arrive at a complete and accurate representation of a sentence, but rather derive an interpretation that is deemed "good enough" for the particular task at hand.

A second, potentially related possibility is that structural cues in the sentence may indicate to the reader that the relation conveyed should be interpreted as presupposed or given, and is thus not as important as relations that are asserted within a clause. For example, in *The memo that the secretary began announced …*, the implication is that the secretary's relation to the memo is background knowledge and is less important than understanding what information was contained in the memo. Similarly, the phrase *What the secretary began* presupposes that some event has already occurred. When the entity NP is asserted as that event (e.g., *the memo*), the strong presupposition due to sentence structure that an appropriate event has already taken place reduces the likelihood that the semantic mismatch between the entity NP and needed event will be detected and therefore reduces the processing cost of coercion. In this way, structural manipulations that indicate to the reader which relationships should be focused on as opposed to those that are simply background knowledge may cue the reader to adopt an underspecified representation of a noncanonical relationship and instead focus deeply on the more prominent relations in the sentence.

The idea that structural manipulations mark a semantic relationship as presupposed might also explain the moderating effects of sentence structure on inanimate subject-verb integration (Lowder & Gordon, 2012) and metonymy (Lowder & Gordon, 2013). For example, in the sentence *The pistol that injured the cowboy remained in the saloon*, the relationship between the sentence subject and the embedded verb seems to serve as background information relative to the information being asserted in the main clause of the sentence. Indeed, this analysis highlights the role of the relative clause as a modifier, or adjunct phrase, as it serves to restrict the identity

of the head noun or further modify its meaning. In a similar way, embedding a metonym in an adjunct phrase (e.g., *The journalist offended the honor of the college*) seems to mark it as presupposed, as though *the college* had already been brought into the discourse and is now being presented as background knowledge so that the more important relationships between the verb and its arguments can occupy the focus of the sentence. Previous work has suggested that presupposed sentential information is less likely to attract attention and be evaluated deeply compared to information that is newly asserted (e.g., Baker & Wagner, 1987; Bredart & Modolo, 1988; Engelkamp & Zimmer, 1982; Hornby, 1974); however, this work has tended to focus on the presupposition or assertion of particular words in the sentence rather than the relationship between multiple constituents.

Conclusion

The psycholinguistic literature on complement coercion, inanimate subject-verb integration, metonymy, and other types of figurative language has tended to characterize these phenomena as distinct. Although the precise mechanisms that lead to successful interpretation of these forms may vary, we believe that they are all similar in that they involve a semantic mismatch at the level of literal meaning. Critically, the structure of the sentence influences the likelihood that the mismatch will be detected and the degree to which additional processing that establishes meaningful relations is performed.

CHAPTER 5: Corpus Study

Experimental work in psycholinguistics is often supplemented by corpus analyses that provide information about the rates of occurrence for a given type of linguistic expression in samples of naturally occurring language. Frequency patterns in corpus data can be compared to reading patterns during online sentence processing in order to determine whether ease of processing is correlated with frequency of occurrence. The experimental work presented in this dissertation (Lowder & Gordon, 2012, 2013, under review) demonstrates that complex semantic expressions are difficult to process when the critical constituents that represent the expression all appear in the same clause of the sentence, but that this difficulty is reduced when one constituent appears in the main clause of the sentence and another appears in a relative clause or another adjunct phrase. The goal of the corpus analyses is to determine whether a corresponding frequency pattern emerges in naturally occurring language. Finding that the constituents of a complex semantic expression occur more frequently across clause boundaries or as part of an adjunct phrase than together in the same clause of the sentence would provide evidence that patterns of language usage correspond with patterns of online processing difficulty. However, because such results are correlational, they do not identify a cause. That is, this outcome could imply that our relative ease of processing complex semantic expressions when they appear across a clause boundary is driven by our greater experience with these expressions in these types of sentence structures. On the other hand, it may be the case that the relative ease of comprehending these constructions causes people to produce them more frequently, or that both

frequency of production and ease of understanding are themselves the consequence of some other factor. Even without knowing the direction of causality, finding such a relationship between the experimental results and the results of the corpus analyses would provide compelling evidence that the processes responsible for both comprehension and production of complex semantic expressions reflect common constraints.

Alternatively, there may be no relationship between ease of comprehension and frequency patterns, or even the opposite pattern of effects such that the more difficult expressions are the ones that appear more frequently. This outcome would suggest that producers of figurative language and other complex semantic expressions do not bury them in defocused sentence positions but instead position them prominently in the sentence. One possible explanation for this pattern would be that when we choose to produce figurative language, we want it to have a noticeable rhetorical effect. Thus, language producers may tend to place these expressions in focused sentence positions, even though the comprehender may have to work a little harder in order to arrive at the intended interpretation.

Corpus

The corpus analyses reported here were conducted using the Corpus of Contemporary American English (COCA; Davies, 2008), a web-based corpus containing over 450 million words sampled from a wide variety of sources (e.g., fiction, magazines, newspapers, academic journals) from 1990-2012 (http://corpus.byu.edu/coca/). COCA has been used frequently in previous linguistic and psycholinguistic studies to investigate a wide variety of linguistic phenomena (e.g., Allen, Pereira, Botvinick, & Goldberg, 2012; Choi & Gordon, 2013; Kuperman & Van Dyke, 2013; Lowder, Choi, & Gordon, 2013; Lowder & Gordon, 2012; Mack, Clifton,

Frazier, & Taylor, 2012; Ramscar, Matlock, & Dye, 2010; Rayner, Slattery, Drieghe, & Liversedge, 2011).[9]

Metonymy and Sentence Structure

Lowder and Gordon (2013) showed that the figurative sense of a familiar place-for-institution metonym (e.g., *The journalist offended the college*) is more difficult to process than the literal sense of the metonym (e.g., *The journalist photographed the college*) or a noun that refers directly to a person (e.g., *The journalist offended the leader*) when the target word appeared as an argument of the verb. This difficulty was reduced when the metonym appeared as part of an adjunct phrase (e.g., *The journalist offended the honor of the college*). To supplement these experimental findings, a corpus analysis was conducted on a sample of place-for-institution metonyms. The 16 familiar metonyms (e.g., *college*, *consulate*) used in Lowder and Gordon came directly from Frisson and Pickering (1999), who had performed their own corpus analysis on the target words, coding each occurrence as "literal" or "figurative." Frisson and Pickering showed that across their set of items, there was no difference in how frequent the literal versus the figurative sense appeared, although there was a great deal of variability across individual items (i.e., some metonyms appeared much more often in a literal context than a figurative context, whereas other metonyms showed the reverse pattern). Importantly, Frisson and Pickering did not code their metonyms on syntactic role, which Lowder and Gordon showed to be a key factor that modulates metonymic processing. The current corpus analysis examines patterns of naturally occurring language to determine whether the syntactic role of a metonym is

[9] Before consulting COCA, I first attempted to conduct the corpus analyses using the Penn Treebank project (Marcus, Marcinkiewicz, & Santorini, 1993), which consists of several corpora (Brown, Wall Street Journal, and Switchboard) that have been carefully parsed and annotated. However, the relatively small size of these corpora (fewer than 5 million words in total) made it impossible to obtain enough tokens to perform the analyses. For example, the metonym *convent* occurs only 12 times in these corpora, and the metonym *consulate* does not occur at all. In addition, there were very few instances of relative clauses with embedded event-selecting verbs (e.g., *The memo that the secretary began…*).

related to the context in which it appears (i.e., whether it is more likely to be used literally or figuratively).

Method

As a first step, the corpus was randomly sampled for 500 instances of each of the 16 words that can be used as familiar metonyms (i.e., *academy, college, consulate, convent, court, embassy, gallery, headquarters, hospital, institute, palace, prison, school, store, treasury, university*). The sentences were then presented to two native-English-speaking linguistics students who were naïve as to the purpose of the study. These coders judged the syntactic role of each metonym according to whether it was an argument of the verb, part of an adjunct phrase, or neither. The coders made a further distinction regarding the specific type of argument (subject, direct object, or indirect object) or adjunct phrase (prepositional phrase or subordinate clause). A token was coded as "neither" if it was used as a modifier (e.g., *college campus, college administration*) or if it otherwise could not be classified as an argument or adjunct. Such a large number of tokens was sampled because many of these metonyms are very frequently used as modifiers (e.g., a majority of the uses of *treasury* are as pre-nominal modifiers: *treasury rates, treasury department, treasury secretary, treasury bonds, treasury notes, treasury securities,* etc.).

The distinction between arguments and adjuncts is not always obvious. For example, in the sentence *John put the book in the room*, the prepositional phrase *in the room* is an argument because the sentence is incomplete without it (i.e., *John put the book*). In contrast, in the sentence *John saw the book in the room*, the prepositional phrase *in the room* is an adjunct because the sentence is complete without it (i.e., *John saw the book*). In samples of naturally occurring language, this distinction can be even more difficult to make. Rules of thumb for

making these judgments have been provided by Schütze and Gibson (1999). The coders were taught these rules and went through several examples before they began coding of the actual materials. For the most part, the coders were presented with different sets of sentences to code, although a randomly selected subset of sentences for each of the metonyms was presented to both coders to assess reliability. Agreement between raters for these items was 88%, and items on which coders disagreed were eliminated.

The tokens that had been labeled as arguments or adjuncts were again randomly sampled to yield 30 arguments and 30 adjuncts for each of the 16 metonyms. These were then presented to the coders, who were instructed to code each according to whether the metonym was being used literally or figuratively. Again, this judgment is not always easy to make, but in general these decisions can be made by paying close attention to the verb phrase. If the relationship between the metonym and the verb can easily be extended to an animate noun and that verb, then the metonym is likely being used in its figurative sense. For example, in the phrases *The White House announced a new strategy*, *The applicants consulted with the university*, or *The patient threatened to sue the hospital*, we can easily swap out the metonym for an animate noun. Here, the figurative sense of the metonym is being evoked by the context. On the other hand, if the relationship between the metonym and the verb cannot easily be extended to an animate noun and that verb, then the metonym is likely being used in its literal sense. For example, in the phrases *The terrorists stormed into the White House*, *The applicants strolled through the university*, or *The patient was admitted to the hospital*, the sentence becomes awkward or anomalous if we try to swap out the metonym for an animate noun. Here, the context of the sentence is evoking the sense of the metonym associated with the literal, physical place. Coders were given several clear examples and several more ambiguous examples to train on and discuss

before coding of the critical items began. Again, the coders were presented with different sets of sentences to code, although a randomly selected subset of sentences for each of the metonyms was presented to both coders to assess reliability. Agreement between raters for these items was 89%, and items on which coders disagreed were eliminated and replaced.

Examples from the corpus of metonyms used in both literal and figurative senses at each sentence position are presented in Table 11.

Analysis

Given that the dependent variable was binomial (i.e., literal or figurative), the data were modeled using logit mixed effects models. This approach allows for analysis of binomial data while simultaneously considering the influence of fixed and random factors (Jaeger, 2008). The data were analyzed in R using the lme4 package for linear mixed effects modeling (Baayen, Davidson, & Bates, 2008; Bates & Sarkar, 2007).

Results

Table 12 shows the frequency of literal and figurative senses of metonyms by grammatical role. Collapsing across grammatical role, there were 581 instances of metonyms being used literally (61%) and 379 instances of metonyms being used figuratively (39%). Modeling these data with only the random effect of metonym (entered as random intercepts) showed a marginally significant difference, $\beta = -0.54$, $SE = 0.29$, $z = -1.85$, $p < .07$. There was a great deal of variability in sense frequency across the various metonyms. For example, *palace* was used literally in 93% of sentences and figuratively in only 7%, whereas *academy* was used literally in 23% of sentences and figuratively in 77%. For 10 of the metonyms, the literal sense was the most frequent; for the remaining six, the figurative sense was the most frequent. These patterns are consistent with Frisson and Pickering (1999), who used a different corpus but still

showed that there was not a reliable difference in the overall frequencies of the literal versus the figurative senses of metonyms when grammatical role was not taken into account.

Table 11
Examples of literal and figurative senses of metonyms by grammatical role

	Literal
Arguments	
Subjects	*The **convent** was immaculate and smelled strongly of floor wax and furniture polish.*
Direct objects	*Kta and Yoshikawa rushed to the **consulate** and, tuning in to Radio Tokyo, heard a weather forecast that included the phrase "East wind, rain"—a prearranged signal that war against the United States was imminent.*
Indirect objects	*So they brought them all to the U.S. **Embassy**, where hundreds wait in line for help.*
Adjuncts	
Prep. phrases	*We often don't have enough drugs in the **hospital**.*
Sub. clauses	*C.A. was a blunt, sociable Ohio boy who left Allegheny **College** after two years, impatient with formal study, to take a job as a salesman in preparation for partnership in his father's maple-syrup cannery in Garrettsville.*
	Figurative
Arguments	
Subjects	*The **convent** hadn't absorbed her completely.*
Direct objects	*According to Tracy, Aramco provided arrested employees with lawyers and informed the **consulate** of the arrest.*
Indirect objects	*According to a highly placed U.S. official, the speech was outlined by Constant's old CIA contact, Kambourian, and handed over to the U.S. **embassy**, which in turn dictated it to Constant, who apparently accepted it without his usual bravado.*
Adjuncts	
Prep. phrases	*But the couple's battle with the **hospital** fueled suspicions that they were trying to delay the criminal investigation.*
Sub. clauses	*He was asked what he sees as the greatest challenge facing City **College** as it nears the 21st century.*

Table 12
Counts of literal and figurative senses of metonyms by grammatical role. Percentages in parentheses represent percentage of tokens classified as literal or figurative within a given row.

	Literal		Figurative		Total
Arguments	257	(54%)	223	(46%)	480
Subjects	50	(26%)	143	(74%)	193
Direct objects	163	(70%)	69	(30%)	232
Indirect objects	44	(80%)	11	(20%)	55
Adjuncts	324	(68%)	156	(32%)	480
Prepositional phrases	199	(67%)	100	(33%)	299
Subordinate clauses	125	(69%)	56	(31%)	181
Total	581	(61%)	379	(39%)	960

An additional model was run that incorporated grammatical role (i.e., whether the metonym appeared in an argument or as part of an adjunct phrase) as a fixed effect and metonym as a random effect. The effect of grammatical role was highly significant, $\beta = 0.77$, $SE = 0.15$, $z = 5.02$, $p < .001$. Although metonyms that appeared as arguments did not differ with respect to whether they were used literally or figuratively, $\beta = -0.17$, $SE = 0.36$, $z = -0.48$, $p > .60$, metonyms that appeared as adjuncts were significantly more likely to be used literally than figuratively, $\beta = -0.87$, $SE = 0.26$, $z = -3.33$, $p < .001$. In addition, a metonym used in its figurative sense was more likely to appear as an argument than as part of an adjunct phrase, $\beta = 0.36$, $SE = 0.10$, $z = 3.43$, $p < .001$, whereas a metonym appearing in its literal sense was more likely to appear as part of an adjunct phrase than as an argument, $\beta = -0.23$, $SE = 0.08$, $z = -2.77$, $p < .01$.

The effect of grammatical role on metonym sense was examined further by considering the specific type of argument or adjunct. First, the proportion of figurative uses was analyzed only for arguments with grammatical role (i.e., subject, direct object, or indirect object) as a fixed

effect and metonym as a random effect. There was a robust effect of grammatical role, β = -1.63, *SE* = 0.21, *z* = -7.82, *p* < .001, reflecting the greater tendency for metonyms to be used figuratively than literally when they appeared as subjects (74% figurative versus 26% literal), but a reversal of this trend when metonyms appeared as direct objects (70% literal versus 30% figurative) or indirect objects (80% literal versus 20% figurative). A similar model was computed for adjuncts with grammatical role (i.e., prepositional phrase or subordinate clause) as a fixed effect and metonym as a random effect. There was no effect of grammatical role, β = -0.06, *SE* = 0.22, *z* = -0.27, *p* > .75, reflecting the greater tendency for metonyms to be used literally than figuratively when they appeared either in a prepositional phrase (67% literal versus 33% figurative) or as part of a subordinate clause (69% literal versus 31% figurative).

Discussion

The results of the corpus analysis show that in general a metonym used in its figurative sense is more likely to appear as an argument than an adjunct, whereas a metonym used in its literal sense is more likely to appear as part of an adjunct phrase than as an argument. This pattern is particularly interesting given that readers tend to experience enhanced online difficulty when encountering the figurative sense of a metonym when it appears as an argument, suggesting perhaps that language producers tend to position figurative expressions prominently in the sentence rather than bury them in a defocused sentence position. Figurative expressions and other complex semantic expressions can be very effective rhetorical devices, and so it seems plausible that language producers may want to highlight these expressions, even though comprehenders may need to exert more processing resources to interpret them.

Closer examination of the data revealed that the greater tendency for figurative uses of metonyms to appear in arguments than adjuncts was driven entirely by metonyms that appeared as sentence subjects. In contrast, metonyms that appeared as direct objects or indirect objects

patterned with adjuncts in having a higher proportion of literal than figurative uses. Thus, the frequency data cannot be easily reconciled with the processing patterns reported by Lowder and Gordon (2013), where the arguments we used were always direct objects and the adjunct phrases we used were always prepositional phrases. Whereas the corpus data reported here show that direct objects and prepositional phrases pattern together in proportions of figurative versus literal senses of a metonym, Lowder and Gordon demonstrate different processing patterns for figurative versus literal senses depending on its sentence structure. I return to this point in the next chapter.

Complement Coercion and Sentence Structure

Lowder and Gordon (under review) showed that the processing difficulty associated with complement coercion is reduced when the event-selecting verb and entity NP appear in separate clauses (e.g., *The memo that the secretary began*) compared to when they appear in the same clause (e.g., *The secretary that began the memo*). Lowder and Gordon also reported the results of a separate completion experiment where participants were presented with sentence fragments (e.g., *The secretary that began the*…; *The memo that the secretary*…) and were instructed to make a complete sentence. The NPs were coded as to whether they corresponded to entities or events, whereas the verbs were coded as to whether they were entity-selecting or event-selecting. Results showed that participants completed the subject-relative clauses (e.g., *The secretary that began the*…) with a mix of entity NPs (e.g., *memo*) and event NPs (e.g., *meeting*), whereas participants almost always completed the object-relative clauses (e.g., *The memo that the secretary*…) with an entity-selecting verb (e.g., *wrote*) and very rarely provided an event-selecting verb (e.g., *began*). Interestingly, this pattern is the opposite of the pattern we obtained in the reading-time data (i.e., readers experience reduced difficulty with a construction like *The*

memo that the secretary began, even though they almost never provide an event-selecting verb as the embedded verb in this construction). The current corpus analysis was conducted to determine whether patterns of natural language correspond more closely to the results we obtained in the reading-time study or the predictability study. Instances of event-selecting verbs embedded in relative clauses were obtained, and their complement NPs were coded according to whether they referred to entities or events.

Method

As a first step, the corpus was randomly sampled for 1,000 instances of each of the 10 event-selecting verbs used in Lowder and Gordon (under review) (i.e., *attempted, began, endured, enjoyed, finished, mastered, preferred, resisted, started, tried*) that appeared in a sentence where it was preceded by a complementizer (i.e., *that, who, which,* or *whom*). The sentences were then presented to two native-English-speaking linguistics students who were naïve as to the purpose of the study. These coders judged whether the target word served as the embedded verb of a subject-extracted relative clause (SRC), the embedded verb of an object-extracted relative clause (ORC), or neither. Such a large number of tokens was sampled because these fairly general search criteria returned many hundreds of constructions that were not actually RCs. These included sentences where the complementizer and target verb appeared in separate clauses (e.g., *They constitute the first West Point student body* ***that*** *contains no cadets enrolled before communism* ***began*** *to crumble*), sentences where the complementizer was used as a demonstrative pronoun (e.g., *Everyone agreed to this, and* ***that*** *was how the adventure* ***began***), and sentences where the complementizer introduced a clause that was not an RC (e.g., *He said* ***that*** *he* ***began*** *to have anxiety attacks when he went on stage*). In addition, SRCs or ORCs where the target verb combined with another verb phrase (e.g., *began to write, began writing*) or where

the target verb was used intransitively (e.g., *The play that began last night was enjoyed by all*) were excluded. Thus, the goal was to obtain a sample of SRCs and ORCs that contained the target verb in the embedded verb position and that also combined with a complement NP, similar to the stimuli used in Lowder and Gordon. The coders were taught these rules and went through several examples before coding of the actual materials began. For the most part, the coders were presented with different sets of sentences to code, although a randomly selected subset of sentences for each of the target verbs was presented to both coders to assess reliability. Agreement between raters for these items was 95%, and items on which coders disagreed were eliminated. Examples from the corpus of valid SRCs and ORCs are presented in Table 13.

Table 13
Examples of SRCs and ORCs

SRCs
*Can you help a man who **attempted** suicide and beat a child?*
*Bushehr was built largely with equipment from Siemens, the German industrial giant that **began** the reactors in the 1970s but later pulled out of the project.*
*Joan, who had just **endured** many months of torment, was watching Kate with real concern.*
*Donny, who **enjoyed** a good cigar from time to time, poured himself another half-cup of coffee.*
*Rose, who on Monday **finished** a five-month prison term for tax felonies, was banned from baseball.*
ORCs
*But both are necessary ingredients in the genre that Ms. Lippman has **mastered** in the last decade.*
*Social preferences were closely tied to church involvement, which older adults **preferred** over other activities.*
*Bazerman and Loewenstein favor an approach that the accounting industry has fiercely **resisted**.*
*Marc found a diary, his mother's diary, which she **started** in 1909 when she was 23.*
*My daughter vetoed a number of the books that we **tried** early on because she felt they were -- though she didn't use this word -- too moralizing.*

The tokens that had been labeled as valid RCs were again randomly sampled to yield 20 SRCs and 20 ORCs for each of the 10 target verbs. The complement NPs for each of these were then presented to the coders without their corresponding sentence contexts (e.g., *suicide, the reactors, the genre, church involvement*). Coders were instructed to decide whether each NP more accurately referred to an entity or an event. This judgment is not always easy to make, but coders were told to code an NP as an "entity" if it represented something that existed or that a person might possess and to code an NP as an "event" if it represented something that could happen and that could be defined by temporal boundaries. Coders were given several examples of entities (e.g., *banana, money, ability, sense of humor*) and of events (e.g., *war, race, hike, meeting*). Coders assigned a value of "0" to NPs referring to entities and "1" to NPs referring to events. Both coders independently judged all of the NPs. Agreement between coders was 86%.

Analysis

Judgments from the coders were averaged together such that each NP received a "0" if both coders rated it an entity, a "1" if both coders rated it an event, and "0.5" if the coders disagreed. Note that this is the same approach we took in analyzing the data for the predictability studies in Lowder and Gordon (under review, Experiments 2 and 3). The ratings were analyzed according to whether the NP had appeared in an SRC or an ORC.

Results

The mean event rating for NPs that appeared in SRCs was 0.63, whereas the mean event rating for NPs that appeared in ORCs was 0.34. This was a highly reliable difference, $F(1, 9) = 28.72$, $p < .001$, reflecting a greater tendency for complement NPs that appear in SRCs with an event-selecting verb to refer to events than entities and a greater tendency for complement NPs that appear in ORCs with an event-selecting verb to refer to entities than events. This pattern

was remarkably consistent across all 10 of the event-selecting verbs sampled from the corpus (see Table 14). The overall pattern suggests that expressions requiring complement coercion (e.g., *began the memo*) are more likely to appear in ORCs (e.g., *The memo that the secretary began*) than in SRCs (e.g., *The secretary that began the memo*).

Table 14
Mean event ratings for NPs appearing in SRCs or ORCs, across different event-selecting verbs

	SRC	ORC
Verbs sampled from corpus		
attempted	0.80	0.40
began	0.88	0.48
endured	0.88	0.75
enjoyed	0.53	0.20
finished	0.90	0.25
mastered	0.28	0.15
preferred	0.23	0.13
resisted	0.55	0.23
started	0.65	0.35
tried	0.40	0.13

Note. A score of "0" was assigned to entity NPs, whereas a score of "1" was assigned to event NPs.

Discussion

The results of the corpus analysis show that expressions requiring complement coercion consisting of an event-selecting verb and an entity-denoting NP are more likely to appear across the clause boundary of an ORC than with both constituents embedded together in an SRC. This pattern is consistent with the reading-time results of Lowder and Gordon (under review), where we showed that the online cost of complement coercion is reduced when integration takes place across a clause boundary compared to when integration takes place within the same clause. This

pattern indicates that at least part of the reason that readers experience reduced difficulty for coercion expressions when the critical constituents appear in separate clauses may stem from the tendency to produce sentences where an entity-denoting NP and event-selecting verb appear in separate clauses, as opposed to positioning them in the same clause.

Interestingly, the results of the corpus analysis do not align with the results of the predictability studies conducted in Lowder and Gordon (under review). In the predictability study that accompanied Experiment 2, participants were extremely unlikely to ever complete a stem like *The memo that the secretary…* with an event-selecting verb, yet participants frequently completed stems like *The secretary that began the…* with an entity-denoting NP. Comparing rates of verb completions with rates of NP completions here is potentially problematic; however, Experiment 3 controlled for this issue by presenting participants with fragments representing clefts (e.g., *It was the secretary that began the…*) and pseudoclefts (e.g., *What the secretary began was the…*) and coding the collected NPs according to whether they were events or entities. There was no indication here that event scores differed across cleft type.

A possible explanation for why the corpus analysis showed different entity/event scores for NPs in ORCs compared to NPs in SRCs may have to do with basic differences in what types of NPs tend to appear in main clauses versus relative clauses. Note that the complement NPs extracted from ORCs always appeared in the main clause of the sentence (e.g., *Marc found **a diary**, his mother's diary, which she started in 1909 when she was 23.*), whereas the complement NPs extracted from SRCs were always embedded within the RC (e.g., *Donny, who enjoyed **a good cigar** from time to time, poured himself another half-cup of coffee.*). It may be the case that inanimate NPs that serve as the head of an RC are more likely to be entities than events simply because they are more likely to modify entities than events with RCs. For example, an entity

like “the memo” may need to be differentiated from many other memos (e.g., *Which memo announced the new pay cuts? The memo that the secretary began*). In contrast, it may be less likely that we need to modify an event NP with an RC in order to differentiate it from other events. For example, a sentence like “*The coffee break that the secretary began lasted five minutes”* suggests that this coffee break needs to be singled out from other coffee breaks. It may be the case that the broader discourse of natural language has already clarified what sort of event is being discussed, making it unlikely that an RC would be needed for additional modification.

CHAPTER 6: Conclusions

The experimental results reported in this dissertation can be summarized as follows. First, readers experience enhanced difficulty processing an expression that contains a semantic mismatch compared to control expressions when the critical constituents share a tight structural relationship (i.e., appearing together in the same clause of the sentence). Second, this processing difficulty is reduced or eliminated completely when one of the critical constituents appears in the main clause of the sentence and another is embedded in a relative clause or some other adjunct phrase. Third, the effect of sentence structure on the processing of complex semantic expressions depends on structural emphasis or deemphasis of the *relationship* between the critical linguistic elements that require a complex interpretation rather than specific constituents. The theoretical implications of each of these findings are discussed in the following sections.

Interpretation of Nonliteral Language

A straightforward combination of the literal meanings of individual words often fails to produce the intended meaning of the expression. Although there have been efforts to understand the mechanisms that allow readers to successfully comprehend nonliteral language, this work has tended to focus on specific expressions individually, without considering ways in which the processing of these various constructions might be similar. Within the realm of figurative-language processing, psycholinguists characterized the standard pragmatic model (Grice, 1975; Searle, 1979) as an indirect-access model (Clark & Lucy, 1975; Janus & Bever, 1985), which proposed that figurative expressions such as metaphor and metonymy are processed according to the following steps: (1) the comprehender computes the literal meaning of the expression using

the stored meanings of lexical entries; (2) the comprehender determines whether the literal meaning of the expression seems appropriate in the broader sentence context or whether it instead seems "defective" (Searle, 1979); and (3) if the literal meaning is defective, the comprehender searches for an alternative meaning. According to the indirect access model, longer reading times for figurative compared to literal expressions are attributed to this sequence of processing stages.

Although this account has typically only been discussed in relation to figurative-language processing, its predictions can easily be expanded to other types of complex semantic expressions. For example, Traxler, McElree, Williams, and Pickering (2005) have proposed that the processing difficulty associated with complement coercion (e.g., *began the memo*) can be attributed to the following sequence of operations: (1) the comprehender accesses the stored lexical entry for the complement noun (e.g., *memo*) and attempts to integrate its meaning with the unfolding meaning of the sentence; (2) the comprehender detects a semantic mismatch between the stored semantic characteristics of the noun and the thematic properties of the verb, which triggers the coercion process; (3) the comprehender attempts to resolve the semantic mismatch by using the context of the sentence to infer an action that could plausibly be performed on the noun; and (4) the comprehender reconfigures the semantic properties of the complement to allow for an event interpretation (e.g., *began writing the memo*). This proposed sequence of processing stages closely resembles the indirect access model, yet Traxler et al. do not explicitly characterize it as such (see also Pylkkänen & McElree, 2006; Pylkkänen, 2008).

I propose that the processing of a wide variety of complex semantic expressions proceeds in a way very similar to the predictions of the indirect access model and Traxler et al.'s explanation of the coercion cost described above: (1) the comprehender makes an initial attempt

to establish meaningful semantic relations based on the stored senses of the words in the sentence, (2) the comprehender detects a semantic mismatch (or "defect") when initial interpretation fails, and (3) the comprehender uses contextual information to resolve the mismatch and ultimately arrive at the intended meaning. The need to detect and resolve the semantic mismatch seems to be common across different types of complex semantic relations; however, the specific mechanisms that lead to detection and resolution of the semantic mismatch may differ depending on the type of expression. For example, whereas a great deal of previous work argues that the cost of complement coercion reflects the time needed to mentally construct semantic representations that are not licensed by the syntax of the sentence (e.g., Frisson & McElree, 2008; McElree et al., 2001; Pickering et al., 2005; Traxler et al., 2002, 2005), work on metonymy argues that readers do not generate additional sentential material, but rather select the figurative sense of a metonym among several possible senses (e.g., Frisson & Pickering, 1999; Clark & Gerrig, 1983; Gerrig, 1989), which may be similar to the process of finding the contextually appropriate meaning of a homonym (e.g., Duffy et al., 1988; Rayner & Duffy, 1986; Rayner & Frazier, 1989; Sereno et al., 1992). The view that different mechanisms are responsible for the interpretation of coercion and metonymy is consistent with the conclusions of previous work (see, e.g., McElree et al., 2006). Critically though, this previous work has tended to argue that the processing of familiar metonyms is cost-free, whereas the processing of coercion is more complex. In contrast to this view, our work shows that the processing of familiar metonyms is not as straightforward as the processing of literal expressions (Lowder & Gordon, 2013), but rather does impose a processing cost, at least when the metonym is in a syntactically prominent position.

Syntax-by-Semantics Interactions

The moderating effect of sentence structure on the processing of complex semantic expressions is not predicted by the indirect access model, although the model does identify the stages of processing where sentence structure might exert its effect. I propose that when the critical constituents of a complex semantic expression are structurally separated, readers are less likely to detect the semantic mismatch or they interpret the semantic relation at a shallow or underspecified level. More specifically, readers may compute the *syntactic* relationship between two semantically mismatched constituents without fully computing their meaning. Initial support for this explanation comes from an eye-tracking experiment we've recently conducted (Lowder & Gordon, 2014a), where instead of manipulating semantic complexity between two constituents, we manipulated the syntactic feature of number agreement. Participants read sentences where the subject and target verb either matched in grammatical number or mismatched, and whether integration occurred within a clause or across a clause boundary, as in (1).

(1a) *The cowboy injures the sheriff in the bar…*

(1b) *The cowboy that injures the sheriff in the bar…*

(1c) *The cowboy injure the sheriff in the bar…*

(1d) *The cowboy that injure the sheriff in the bar…*

(1e) *The cowboys injures the sheriff in the bar…*

(1f) *The cowboys that injures the sheriff in the bar…*

(1g) *The cowboys injure the sheriff in the bar…*

(1h) *The cowboys that injure the sheriff in the bar…*

In general, readers showed a higher proportion of regressive saccades and longer regression-path durations at the verb (e.g., *injure*/*injures*) when the subject and verb mismatched in grammatical number than when they matched. Critically, this effect was *larger* when integration took place inside a relative clause than when integration took place locally within a single clause. This pattern suggests that readers are concerned with computing accurate syntactic relations across clause boundaries. Considering these results along with our experiments on semantic complexities (Lowder & Gordon, 2012, 2013, under review), it seems plausible to propose that readers compute the syntactic relationship between two semantically mismatched constituents (e.g., *The memo that the secretary began announced…*), but do not process the meaning of the relation at a deep level (e.g., "The secretary had something to do with the memo").

It is also important to note that the structural manipulations employed in these experiments may have served as cues to the readers that some linguistic information should be interpreted as presupposed or given, compared to information being newly asserted in the sentence. For example, relative clauses typically convey information that is presupposed or given by a previous discourse context (e.g., Fox & Thompson, 1990; Gordon & Hendrick, 2005), whereas the linguistic material presented in the main clause is likely seen as the more important information. This perspective explains why readers do not spend as much time processing the semantic relation between an inanimate subject and an action verb (e.g., *The pistol that injured the cowboy was in the saloon*) or an event-selecting verb and an entity NP (e.g., *The memo that the secretary began announced the pay cuts*) when the verb is embedded in an RC compared to when it is in the main clause of the sentence. That is, the relation between the sentence subject and embedded verb is perhaps interpreted as background knowledge compared to the information being asserted in the main clause of the sentence. Similarly, embedding a metonym

in an adjunct phrase (e.g., *The journalist offended the honor of the college*) seems to indicate that the information it contains is presupposed, as the phrase "of the college" implies that "the college" had already been part of the discourse and is now appearing in the sentence to modify a new entity (e.g., "the honor"). In this way, readers may use these structural cues to determine which parts of the sentence are more important to focus on than others, leading to shallow or underspecified interpretations of some semantic relationships.

The comprehension questions that followed sentences in the experiments discussed here were not designed to probe whether readers had arrived at the intended interpretation of the complex expression. However, future work must begin to characterize the types of representations readers adopt when linguistic material is integrated across multiple clauses. If it is the case that readers process the meaning of a complex expression at a shallower level when it spans two clauses, then we should be able to obtain evidence that comprehension for this material is lower or perhaps subsequent memory for this linguistic relationship is poor compared to expressions that are integrated locally within a single clause. Indeed, having established that less time is spent reading complex semantic expressions that span multiple clauses, the next step is to better understand what the consequences are for comprehension or memory of this material.

Structural Manipulation of Linguistic Relationships

Sentence structure has been shown to be a powerful device for marking a particular linguistic element as "focused" or "prominent" (i.e., to emphasize the most important information in the sentence). For example, in the cleft sentence *It was the secretary that wrote the memo*, the word "secretary" is considered to be in linguistic focus, whereas in the pseudocleft *What the secretary typed was the memo*, the word "memo" is in linguistic focus. A large body of literature spanning multiple subareas of cognitive psychology has demonstrated that

linguistically focused information enjoys a number of cognitive benefits relative to information that is not focused. Linguistic focus attracts attention (Carpenter & Just, 1977; Hornby, 1974; Langford & Holmes, 1979; Sturt et al., 2004; Zimmer & Engelkamp, 1981), improves anomaly detection (Baker & Wagner, 1987, Bredart & Modolo, 1988), enhances memory (Birch et al., 2000; Birch & Garnsey, 1995; McKoon, Ratcliff, Ward, & Sproat, 1993; Singer, 1976), and facilitates anaphor resolution (Almor, 1999; Foraker & McElree, 2007). In addition, readers tend to spend more time processing focused compared to nonfocused information (Benatar & Clifton, 2014; Birch & Rayner, 1997; Lowder & Gordon, 2014b; Price & Sanford, 2012, cf. Birch & Rayner, 2010; Morris & Folk, 1998). Critically, research on linguistic focus has tended to investigate the processing of focused or defocused individual words rather than relationships between multiple constituents in a single sentence. As we demonstrated (Lowder & Gordon, under review, Experiment 1), although readers spent less time reading words that were embedded in an RC compared to a main clause (e.g., *The secretary wrote/began the memo* vs. *The secretary that wrote/began the memo*), this manipulation had no effect on the magnitude of the coercion cost, suggesting that readers still computed the complex relationship between these constituents when both of them were deemphasized. Similarly, readers spent more time processing the complement NP when it was focused by the pseudocleft (e.g., *What the secretary wrote/began was the memo*) compared to when the cleft focused a different NP (e.g., *It was the secretary that wrote/began the memo*), suggesting that the pseudocleft did mark "the memo" as the most important constituent in the sentence. However, the magnitude of the coercion cost was reduced when the verb and complement appeared in separate clauses in the pseudocleft compared to when they appeared in the same clause in the cleft. These patterns of results demonstrate that it is important to consider how sentence structure can emphasize or

deemphasize semantic *relationships* between various constituents and how the focus of a single sentential element may change its relation to other elements in the sentence.

Complex Semantic—Syntactic Relationships in Naturally Occurring Language

The corpus analyses described in Chapter 5 do not correspond to our previous experimental findings in a straightforward way. On the one hand, analysis of the frequency patterns of complement coercion in SRCs and ORCs showed convincingly that language producers are more likely to position an entity-denoting NP and an event-selecting verb in separate clauses (e.g., *The memo that the secretary began*) than to position the two constituents together in an RC (e.g., *The secretary that began the memo*), which is consistent our finding that structural separation reduces the processing difficulty of complement coercion (Lowder & Gordon, under review). On the other hand, analysis of the frequency patterns of familiar metonyms showed that the distribution of literal versus figurative uses was practically identical for direct-object arguments (e.g., *The journalist offended the college*) and prepositional-phrase adjuncts (e.g., *The journalist offended the honor of the college*), although we showed a clear difference between these two structures in online processing times (Lowder & Gordon, 2013). The different patterns between coercion and metonymy in corpus counts perhaps provides further evidence that these two types of semantic mismatches are processed using very different cognitive mechanisms. However, the corpus results for metonymy suggest that additional experimental work needs to be done that more carefully considers different types of arguments. Recall that the corpus analysis showed a reversal in literal versus figurative patterns for sentence subjects and direct objects: whereas only 30% of direct-object metonyms were used figuratively, 74% of metonyms in subject position were used figuratively. It is an open question whether this difference in frequency patterns corresponds to different online reading patterns. On the one

hand, the greater proportion of figurative versus literal metonyms in subject position might suggest that readers would have less processing difficulty compared to when the metonym appears as a direct object. On the other hand, it may still be the case that readers experience enhanced difficulty when a figurative expression appears as the subject of the sentence. This latter outcome would be consistent with the notion that language producers place complex semantic expressions in focused sentence positions to elicit a noticeable rhetorical effect, even though the comprehender may have to exert extra processing effort to arrive at the intended interpretation.

APPENDIX 1: STIMULI USED IN LOWDER AND GORDON (2012) EXPERIMENT 1

The stimuli from Experiment 1 are shown below in their object-extracted forms with both animate and inanimate embedded NPs. Each stimulus was also presented in its subject-extracted form, as described in the text.

1. The guide that the {hikers/avalanche} buried appeared on the six o'clock news.
2. The peasant that the {farmer/tractor} ran over assisted with the harvest every year.
3. The sheriff that the {cowboy/pistol} injured persuaded the members of the jury.
4. The bicyclist that the {woman/accident} crippled caused a number of serious injuries.
5. The intruder that the {plumber/wrench} bruised remained near the back door.
6. The policeman that the {burglar/revolver} shot remained in the bedroom.
7. The hobo that the {boys/church} sheltered looked very shabby.
8. The neighbors that the {kids/pizza} fed stayed in the basement all night.
9. The maiden that the {farmer/crops} fed died after the early frost.
10. The toddlers that the {girls/feathers} tickled came from South Africa.
11. The journalist that the {senator/article} accused caused a scandal after the election.
12. The foreigner that the {student/school} taught requested financial support.
13. The acrobats that the {people/train} carried traveled to several major cities last year.
14. The captain that the {pilot/helicopter} carried died on the way to the hospital.
15. The commander that the {engineer/rocket} lifted continued to assist NASA for many years.
16. The gladiator that the {warrior/spear} impaled attracted the attention of the crowd.
17. The manager that the {worker/machine} injured cost the company time and money.
18. The teenager that the {woman/water} scalded irritated everyone in the kitchen.
19. The lady that the {actress/jewelry} decorated received a lot of attention at the party.
20. The officer that the {punk/knife} wounded became an important part of the trial.
21. The rebels that the {soldiers/camp} housed covered a large part of the forest.
22. The vagrant that the {leper/medicine} treated made several others sick.
23. The architect that the {expert/machinery} assisted detected a flaw in the metal.
24. The citizen that the {cowboy/rope} hanged became a symbol of the revolution.
25. The villain that the {actor/razor} shaved appeared in several horror movies.
26. The supervisor that the {prospector/metal} poisoned arrived from Texas last year.

27. The technician that the {scientist/chemical} sickened worried many others in the lab.
28. The spies that the {soldiers/fort} protected saved the city from the enemy.
29. The gangsters that the {wrestlers/tattoos} covered intimidated everyone in the bar.
30. The employee that the {executive/airplane} transported flew to Chicago once a year.

APPENDIX 2: STIMULI USED IN LOWDER AND GORDON (2012) EXPERIMENT 2

1. The {hikers that fled the avalanche/avalanche that buried the hikers} appeared on the six o'clock news.
   The {hikers fled the avalanche/avalanche buried the hikers} on the side of the mountain.
2. The {farmer that washed the tractor/tractor that ran over the farmer} was standing next to the barn.
   The {farmer washed the tractor/tractor ran over the farmer} next to the barn.
3. The {cowboy that concealed the pistol/pistol that injured the cowboy} was known to be unreliable.
   The {cowboy concealed the pistol/pistol injured the cowboy} last night in the saloon.
4. The {woman that triggered the accident/accident that crippled the woman} caused a number of serious injuries.
   The {woman triggered the accident/accident crippled the woman} on the busy highway.
5. The {plumber that gripped the wrench/wrench that bruised the plumber} was found near the back door.
   The {plumber gripped the wrench/wrench bruised the plumber} near the back door.
6. The {burglar that found the revolver/revolver that shot the burglar} was in the bedroom.
   The {burglar found the revolver/revolver shot the burglar} in the bedroom.
7. The {boys that vandalized the church/church that sheltered the boys} looked very shabby.
   The {boys vandalized the church/church sheltered the boys} several times last winter.
8. The {girls that climbed the trees/trees that shaded the girls} were in the back yard.
   The {girls climbed the trees/trees shaded the girls} in the back yard.
9. The {chef that measured the flour/flour that covered the chef} won a prize at the state fair.
   The {chef measured the flour/flour covered the chef} during the competition at the state fair.
10. The {kids that ate the pizza/pizza that fed the kids} stayed in the basement all night.
    The {kids ate the pizza/pizza fed the kids} in the basement all night.
11. The {farmer that planted the crops/crops that fed the farmer} died after the early frost.
    The {farmer planted the crops/crops fed the farmer} after the early frost.
12. The {girls that gathered the feathers/feathers that tickled the girls} were from South Africa.
    The {girls gathered the feathers/feathers tickled the girls} in the African village.
13. The {gangster that concealed the acid/acid that dissolved the gangster} came up during the trial.
    The {gangster concealed the acid/acid dissolved the gangster} in the abandoned warehouse downtown.
14. The {senator that skimmed the article/article that accused the senator} was forgotten after the election.

The {senator skimmed the article/article accused the senator} before the scandal unfolded.

15. The {student that attended the school/school that taught the student} was visited by the governor.
    The {student attended the school/school taught the student} for several years.
16. The {patients that chewed the pills/pills that healed the patients} were mentioned in the medical journal.
    The {patients chewed the pills/pills healed the patients} in the hospital downtown.
17. The {people that rode the train/train that carried the people} arrived at the station early.
    The {people rode the train/train carried the people} to every circus performance.
18. The {drug dealer that damaged the street light/street light that illuminated the drug dealer} stood on the corner of Oak and Jefferson.
    The {drug dealer damaged the street light/street light illuminated the drug dealer} on the corner of Oak and Jefferson.
19. The {pilot that flew the helicopter/helicopter that carried the pilot} crashed near the grocery store.
    The {pilot flew the helicopter/helicopter carried the pilot} into a dangerous wind storm.
20. The {engineer that designed the rocket/rocket that lifted the engineer} flew over the wildlife preserve.
    The {engineer designed the rocket/rocket lifted the engineer} several days ahead of schedule.
21. The {warrior that hurled the spear/spear that impaled the warrior} was photographed by the historian.
    The {warrior hurled the spear/spear impaled the warrior} during the fight at the Coliseum.
22. The {worker that repaired the machine/machine that injured the worker} cost the company time and money.
    The {worker repaired the machine/machine injured the worker} several months ago.
23. The {woman that prepared the water/water that scalded the woman} stayed in the bathtub for hours.
    The {woman prepared the water/water scalded the woman} in the bathtub.
24. The {actress that purchased the jewelry/jewelry that decorated the actress} got a lot of attention at the movie premiere.
    The {actress purchased the jewelry/jewelry decorated the actress} at the movie premiere.
25. The {punk that brandished the knife/knife that wounded the punk} was hidden under the stairs.
    The {punk brandished the knife/knife wounded the punk} in a dark alley downtown.
26. The {soldiers that built the camp/camp that housed the soldiers} covered a large part of the forest.
    The {soldiers built the camp/camp housed the soldiers} in another part of the forest.

27. The {leper that swallowed the medicine/medicine that treated the leper} stayed in the operating room.
    The {leper swallowed the medicine/medicine treated the leper} in the operating room.

28. The {secretary that drove the car/car that crushed the secretary} cost the insurance company a fortune.
    The {secretary drove the car/car crushed the secretary} on the icy roads.

29. The {expert that operated the machinery/machinery that assisted the expert} detected a flaw in the metal.
    The {expert operated the machinery/machinery assisted the expert} without causing any accidents.

30. The {cowboy that held the rope/rope that hanged the cowboy} was strong and tough.
    The {cowboy held the rope/rope hanged the cowboy} in the center of the town.

31. The {actor that bought the razor/razor that shaved the actor} appeared in the horror movie.
    The {actor bought the razor/razor shaved the actor} in the very first scene of the horror movie.

32. The {prospector that mined the metal/metal that poisoned the prospector} didn't harm the animals.
    The {prospector mined the metal/metal poisoned the prospector} in the dark cavern.

33. The {scientist that patented the chemical/chemical that sickened the scientist} came from Australia.
    The {scientist patented the chemical/chemical sickened the scientist} at an office in Australia.

34. The {soldiers that occupied the fort/fort that protected the soldiers} saved the city from the enemy.
    The {soldiers occupied the fort/fort protected the soldiers} to save the city from the enemy.

35. The {campers that built the fire/fire that warmed the campers} burned down the cabin.
    The {campers built the fire/fire warmed the campers} near the middle of the campgrounds.

36. The {tourist that brought the electric fan/electric fan that cooled the tourist} was a nuisance for the maid.
    The {tourist brought the electric fan/electric fan cooled the tourist} on the African safari.

37. The {mechanic that changed the oil/oil that splashed the mechanic} left a stain on the front seat.
    The {mechanic changed the oil/oil splashed the mechanic} at the garage around the corner.

38. The {technician that replaced the brake fluid/brake fluid that soaked the technician} filled the can next to the hoist.
    The {technician replaced the brake fluid/brake fluid soaked the technician} next to the hoist.

39. The {wrestlers that displayed the tattoos/tattoos that covered the wrestlers} were as ugly as they could be.
    The {wrestlers displayed the tattoos/tattoos covered the wrestlers} as part of a publicity stunt.

40. The {executive that borrowed the airplane/airplane that transported the executive} vanished into thin air.
    The {executive borrowed the airplane/airplane transported the executive} and was never seen again.

APPENDIX 3: STIMULI USED IN LOWDER AND GORDON (2013) EXPERIMENT 1

The stimuli from Experiment 1 are shown below. Within each set, the first sentence represents the literal context, whereas the second sentence represents the figurative context. Within the brackets, the first NP has a familiar metonymic sense, whereas the second NP does not.

1. With determination, the two women purchased {the convent/the stadium} at the end of last April, which upset quite a lot of people.

   With determination, the two women disobeyed {the convent/the stadium} at the end of last March, but did not get a lot of support.

2. Those angry protestors surrounded {the embassy/the cottage}, but not much was achieved by it.

   Those angry protestors debated {the embassy/the cottage}, but not much more could be done.

3. Finally some of the workmen painted {the store/the sheds}, which really made everything look prettier.

   Finally some of the workmen thanked {the store/the sheds}, which really was a nice gesture by them.

4. This morning, terrorists bombed {the prison/the statue} in order to gain publicity for their cause.

   This morning, terrorists threatened {the prison/the statue} in order to make their point a bit clearer.

5. Enthusiastically, the young children approached {the school/the bridge} quite early on a sunny Wednesday morning.

   Enthusiastically, the young children questioned {the school/the bridge} quite early on a rainy Monday afternoon.

6. To my dismay, the agitated senator damaged {the headquarters/the conservatory}, which was something none of us had been waiting for.

   To my dismay, the agitated senator obeyed {the headquarters/the conservatory}, which was something nobody could have prevented.

7. That same day, the husband located {the hospital/the driveway} as soon as he had been informed about the accident.

   That same day, the husband sued {the hospital/the driveway} as soon as he had heard about the mistake that was made.

8. Over the summer, the writer photographed {the college/the pyramid} after he had received an official invitation.

   Over the summer, the writer offended {the college/the pyramid} after he had bribed some crooked officials.

9. Last week the professor entered {the academy/the bedroom}, exactly as everyone had expected him to do.

   Last week the professor addressed {the academy/the bedroom}, exactly as I had wished that he would do.

10. Within an hour, that gentleman accessed {the palace/the cellar}, according to the newspapers this morning.

    Within an hour, that gentleman displeased {the palace/the cellar}, according to the latest gossip in the tabloids.

11. Two days ago, the criminal destroyed {the consulate/the apartment}, but then he got arrested the same day.

    Two days ago, the criminal notified {the consulate/the apartment}, but then he ran away in a great hurry.

12. During the protest, the strikers encircled {the institute/the roadblock}, which was not something that I advised them to do.

    During the protest, the strikers insulted {the institute/the roadblock}, which was not a very sensible idea after all.

13. An hour later, the businessmen found {the treasury/the building}, which was not what we had anticipated.

    An hour later, the businessmen greeted {the treasury/the building}, which was not exactly what we wanted.

14. Sometime last night the thief escaped {the court/the tower}, just as his accomplice had done before him.

    Sometime last night the thief provoked {the court/the tower}, just as his partner had instructed him to do.

15. During vacation, those British visitors toured {the gallery/the highway} and did not encounter any major problems.

    During vacation, those British visitors scolded {the gallery/the highway} and did not exactly enjoy the experience.

16. On Labor Day, many sightseers explored {the university/the lighthouse}, although it was an official holiday.

    On Labor Day, many sightseers contacted {the university/the lighthouse}, although it was late in the afternoon.

17. To my amazement, the executives purchased {the convent/the stadium} at the end of last April, which upset quite a lot of people.

    To my amazement, the executives disobeyed {the convent/the stadium} at the end of last March, but did not get a lot of support.

18. Three days ago, the activists surrounded {the embassy/the cottage}, but not much was achieved by it.

Three days ago, the activists debated {the embassy/the cottage}, but not much more could be done.

19. Reluctantly one of the boys painted {the store/the sheds}, which really made everything look prettier.

    Reluctantly one of the boys thanked {the store/the sheds}, which really was a nice gesture by him.

20. Last year rebels bombed {the prison/the statue} in order to gain publicity for their cause.

    Last year rebels threatened {the prison/the statue} in order to make their point a bit clearer.

21. After the incident, the concerned father approached {the school/the bridge} quite early on a sunny Wednesday morning.

    After the incident, the concerned father questioned {the school/the bridge} quite early on a rainy Monday afternoon.

22. To my surprise, the guards damaged {the headquarters/the conservatory}, which was something none of us had been waiting for.

    To my surprise, the guards obeyed {the headquarters/the conservatory}, which was something nobody could have prevented.

23. With tears in her eyes, the mother located {the hospital/the driveway} as soon as she had been informed about the accident.

    With tears in her eyes, the mother sued {the hospital/the driveway} as soon as she had heard about the mistake that was made.

24. Sometime in August, the journalist photographed {the college/the pyramid} after he had received an official invitation.

    Sometime in August, the journalist offended {the college/the pyramid} after he had bribed some crooked officials.

25. Yesterday afternoon the dean entered {the academy/the bedroom}, exactly as everyone had expected him to do.

    Yesterday afternoon the dean addressed {the academy/the bedroom}, exactly as I had wished that he would do.

26. One year ago, the reporter accessed {the palace/the cellar}, according to the newspapers this morning.

    One year ago, the reporter displeased {the palace/the cellar}, according to the latest gossip in the tabloids.

27. Last Tuesday, the traveler destroyed {the consulate/the apartment}, but then he got arrested the same day.

    Last Tuesday, the traveler notified {the consulate/the apartment}, but then he ran away in a great hurry.

28. At the riot, the teenagers encircled {the institute/the roadblock}, which was not something that I advised them to do.

    At the riot, the teenagers insulted {the institute/the roadblock}, which was not a very sensible idea after all.

29. Before the interview, the applicants found {the treasury/the building}, which was not what we had anticipated.

    Before the interview, the applicants greeted {the treasury/the building}, which was not exactly what we wanted.

30. Before sunrise, the drug smuggler escaped {the court/the tower}, just as his accomplice had done before him.

    Before sunrise, the drug smuggler provoked {the court/the tower}, just as his partner had instructed him to do.

31. For two hours, the expert toured {the gallery/the highway} and did not encounter any major problems.

    For two hours, the expert scolded {the gallery/the highway} and did not exactly enjoy the experience.

32. On Tuesday, several tourists explored {the university/the lighthouse}, although it was an official holiday.

    On Tuesday, several tourists contacted {the university/the lighthouse}, although it was late in the afternoon.

APPENDIX 4: STIMULI USED IN LOWDER AND GORDON (2013) EXPERIMENT 2

The stimuli from Experiment 2 are shown below. Within each set, the critical NP in the first sentence is a person, whereas the critical NP in the second sentence is a metonym. Each sentence was presented with and without the material in the parentheses such that the critical NP could be the object of the verb or part of an adjunct phrase.

1. With determination, the two women disobeyed (the commands of) the priest at the end of last April, which upset quite a lot of people.

   With determination, the two women disobeyed (the commands of) the convent at the end of last March, but did not get a lot of support.

2. Those angry protestors debated (the opinions of) the governor, but not much was achieved by it.

   Those angry protestors debated (the opinions of) the embassy, but not much more could be done.

3. Finally some of the workmen thanked (the clerk sent by) the manager, which really made everyone happier.

   Finally some of the workmen thanked (the clerk sent by) the store, which really was a nice gesture by them.

4. This morning, terrorists threatened (the competence of) the mayor in order to gain publicity for their cause.

   This morning, terrorists threatened (the competence of) the prison in order to make their point a bit clearer.

5. Enthusiastically, the young children questioned (the actions of) the teacher quite early on a sunny Wednesday morning.

   Enthusiastically, the young children questioned (the actions of) the school quite early on a rainy Monday afternoon.

6. To my dismay, the agitated senator obeyed (the orders of) the chairman, which was something none of us had been waiting for.

   To my dismay, the agitated senator obeyed (the orders of) the headquarters, which was something nobody could have prevented.

7. That same day, the husband sued (the student working for) the doctor as soon as he had been informed about the accident.

   That same day, the husband sued (the student working for) the hospital as soon as he had heard about the mistake that was made.

8. Over the summer, the writer offended (the honor of) the leader after he had published that negative article.

Over the summer, the writer offended (the honor of) the college after he had bribed some crooked officials.

9. Last week the professor addressed (the concerns of) the secretary, exactly as everyone had expected him to do.

   Last week the professor addressed (the concerns of) the academy, exactly as I had wished that he would do.

10. Within an hour, that gentleman displeased (the mood of) the queen, according to the newspapers this morning.

    Within an hour, that gentleman displeased (the mood of) the palace, according to the latest gossip in the tabloids.

11. Two days ago, the criminal notified (a representative of) the diplomat, but then he got arrested the same day.

    Two days ago, the criminal notified (a representative of) the consulate, but then he ran away in a great hurry.

12. During the protest, the strikers insulted (the reputation of) the president, which was not something that I advised them to do.

    During the protest, the strikers insulted (the reputation of) the institute, which was not a very sensible idea after all.

13. An hour later, the businessmen greeted (the interns sent by) the director, which was not what we had anticipated.

    An hour later, the businessmen greeted (the interns sent by) the treasury, which was not exactly what we wanted.

14. Sometime last night the thief provoked (the authority of) the judge, just as his accomplice had done before him.

    Sometime last night the thief provoked (the authority of) the court, just as his partner had instructed him to do.

15. During vacation, those British visitors scolded (the policies of) the curator and did not encounter any resistance.

    During vacation, those British visitors scolded (the policies of) the gallery and did not exactly enjoy the experience.

16. On Labor Day, many sightseers contacted (the guides sent by) the administrator, although it was an official holiday.

    On Labor Day, many sightseers contacted (the guides sent by) the university, although it was late in the afternoon.

17. To my amazement, the executives disobeyed (the commands of) the priest at the end of last April, which upset quite a lot of people.

    To my amazement, the executives disobeyed (the commands of) the convent at the end of last March, but did not get a lot of support.

18. Three days ago, the activists debated (the opinions of) the governor, but not much was achieved by it.

    Three days ago, the activists debated (the opinions of) the embassy, but not much more could be done.

19. Reluctantly one of the boys thanked (the clerk sent by) the manager, which really made everyone happier.

    Reluctantly one of the boys thanked (the clerk sent by) the store, which really was a nice gesture by him.

20. Last year rebels threatened (the competence of) the mayor in order to gain publicity for their cause.

    Last year rebels threatened (the competence of) the prison in order to make their point a bit clearer.

21. After the incident, the concerned father questioned (the actions of) the teacher quite early on a sunny Wednesday morning.

    After the incident, the concerned father questioned (the actions of) the school quite early on a rainy Monday afternoon.

22. To my surprise, the guards obeyed (the orders of) the chairman, which was something none of us had been waiting for.

    To my surprise, the guards obeyed (the orders of) the headquarters, which was something nobody could have prevented.

23. With tears in her eyes, the mother sued (the student working for) the doctor as soon as she had been informed about the accident.

    With tears in her eyes, the mother sued (the student working for) the hospital as soon as she had heard about the mistake that was made.

24. Sometime in August, the journalist offended (the honor of) the leader after he had published that negative article.

    Sometime in August, the journalist offended (the honor of) the college after he had bribed some crooked officials.

25. Yesterday afternoon the dean addressed (the concerns of) the secretary, exactly as everyone had expected him to do.

    Yesterday afternoon the dean addressed (the concerns of) the academy, exactly as I had wished that he would do.

26. One year ago, the reporter displeased (the mood of) the queen, according to the newspapers this morning.

    One year ago, the reporter displeased (the mood of) the palace, according to the latest gossip in the tabloids.

27. Last Tuesday, the traveler notified (a representative of) the diplomat, but then he got arrested the same day.

Last Tuesday, the traveler notified (a representative of) the consulate, but then he ran away in a great hurry.

28. At the riot, the teenagers insulted (the reputation of) the president, which was not something that I advised them to do.

    At the riot, the teenagers insulted (the reputation of) the institute, which was not a very sensible idea after all.

29. Before the interview, the applicants greeted (the interns sent by) the director, which was not what we had anticipated.

    Before the interview, the applicants greeted (the interns sent by) the treasury, which was not exactly what we wanted.

30. Before sunrise, the drug smuggler provoked (the authority of) the judge, just as his accomplice had done before him.

    Before sunrise, the drug smuggler provoked (the authority of) the court, just as his partner had instructed him to do.

31. For two hours, the expert scolded (the policies of) the curator and did not encounter any resistance.

    For two hours, the expert scolded (the policies of) the gallery and did not exactly enjoy the experience.

32. On Tuesday, several tourists contacted (the guides sent by) the administrator, although it was an official holiday.

    On Tuesday, several tourists contacted (the guides sent by) the university, although it was late in the afternoon.

APPENDIX 5: STIMULI USED IN LOWDER AND GORDON (UNDER REVIEW) EXPERIMENT 1

The stimuli from Experiment 1 are shown below. Within each set, the first sentence displays the Simple-Sentence condition, whereas the second sentence displays the SRC condition. Within the brackets, the first verb was used in the Control condition, whereas the second verb was used in the Coercion condition.

1. The engineer {read/started} the memo last week and had to send it to the employees today.

   The engineer that {read/started} the memo last week had to send it to the employees today.

2. The girl {ate/tried} the soup at the restaurant while visiting friends.

   The girl that {ate/tried} the soup at the restaurant was visiting friends.

3. The secretary {wrote/began} the memo about the new office policy shortly after being hired.

   The secretary that {wrote/began} the memo about the new office policy had just been hired.

4. The editor {read/finished} the article about tax increases before going home for dinner.

   The editor that {read/finished} the article about tax increases went home for dinner.

5. The architect {designed/finished} the house on time and met with the contractor.

   The architect that {designed/finished} the house on time met with the contractor.

6. The stylist {braided/started} the braid in the girl's hair after brushing it first.

   The stylist that {braided/started} the braid in the girl's hair had brushed it first.

7. The designer {designed/began} the kitchen in the house next door but was worried she wouldn't finish.

   The designer that {designed/began} the kitchen in the house next door was worried she wouldn't finish.

8. The editor {edited/finished} the newspaper first thing in the morning and went home early.

   The editor that {edited/finished} the newspaper first thing in the morning went home early.

9. The publisher {read/began} the novel written by Mark Twain's son, hoping he could publish it.

   The publisher that {read/began} the novel written by Mark Twain's son hoped he could publish it.

10. The student {wrote/tried} the papers assigned for class but did not receive a good grade.

    The student that {wrote/tried} the papers assigned for class did not receive a good grade.

11. The critic {criticized/started} the portrait in the gallery, saying that it reminded him of Picasso.

    The critic that {criticized/started} the portrait in the gallery said it reminded him of Picasso.

12. The guard {closed/finished} the gates on the property before going home for the night.

    The guard that {closed/finished} the gates on the property went home for the night.

13. The woman {planted/started} the garden after the last winter frost and always grew beautiful flowers.

    The woman that {planted/started} the garden after the last winter frost always grew beautiful flowers.

14. The farmer {plowed/started} the fields in the early spring months and always had a successful harvest.

    The farmer that {planted/started} the fields in the early spring months always had a successful harvest.

15. The waitress {made/started} the coffee when the customers walked in and was praised by her manager.

    The waitress that {made/started} the coffee when the customers walked in was praised by her manager.

16. The director {read/started} the script for the action movie and was excited to begin filming.

    The director that {read/started} the script for the action movie was excited to begin filming.

17. The banker {drank/started} the coffee in the break room because he didn't get much sleep last night.

    The banker that {drank/started} the coffee in the break room didn't get much sleep last night.

18. The teacher {recorded/started} the grades before report cards went out and was seen as very hardworking.

    The teacher that {recorded/started} the grades before report cards went out was seen as very hardworking.

19. The professor {wrote/finished} the syllabus for his class but also needed to write up his lectures.

    The professor that {wrote/finished} the syllabus for his class also needed to write up his lectures.

20. The lawyer {drove/preferred} the convertible with the fine leather seats after she worked her way up to the top.

The lawyer that {drove/preferred} the convertible with the fine leather seats had worked her way up to the top.

21. The publisher {read/started} the manuscript two days ago, then gave it to the editor.

    The publisher that {read/started} the manuscript two days ago gave it to the editor.

22. The lawyer {defended/endured} the defendant during the trial but thought he was guilty.

    The lawyer that {defended/endured} the defendant during the trial thought he was guilty.

23. The doctor {wrote/began} the prescription for the new cold medicine but didn't know how expensive it was.

    The doctor that {wrote/began} the prescription for the new cold medicine didn't know how expensive it was.

24. The auditor {audited/began} the taxes for the company and finished by early April.

    The auditor that {audited/began} the taxes for the company finished by early April.

25. The surfer {wore/endured} the tuxedo at the wedding but felt very uncomfortable.

    The surfer that {wore/endured} the tuxedo at the wedding felt very uncomfortable.

26. The nurse {wore/preferred} the velvet made in India but agreed that it was too expensive.

    The nurse that {wore/preferred} the velvet made in India agreed that it was too expensive.

27. The child {wrote/began} the letter for Santa Claus and hoped it would get to him before Christmas.

    The child that {wrote/began the letter for Santa Claus hoped it would get to him before Christmas.

28. The pilot {flew/preferred} the biplane on long trips and argued that it was quite safe.

    The pilot that {flew/preferred} the biplane on long trips argued that it was quite safe.

29. The journalist {wrote/began} the article about the hurricane after he witnessed the destruction firsthand.

    The journalist that {wrote/began} the article about the hurricane had witnessed the destruction firsthand.

30. The builder {built/started} the house for his family and hired a landscaper to do the yard.

    The builder that {built/started} the house for his family hired a landscaper to do the yard.

31. The mechanic {repaired/finished} the truck ahead of schedule and started to work on the car.

    The mechanic that {repaired/finished} the truck ahead of schedule started to work on the car.

32. The dieter {ate/resisted} the cake at the birthday party and ate baby carrots all week.

    The dieter that {ate/resisted} the cake at the birthday party had eaten baby carrots all week.

33. The teenager {read/began} the novel about vampires and had a hard time falling asleep that night.

    The teenager that {read/began} the novel about vampires had a hard time falling asleep that night.

34. The student {read/finished} the book about sailing and was eager to try out her new skills.

    The student that {read/finished} the book about sailing was eager to try out her new skills.

35. The robber {stole/attempted} the necklace at the museum but was spotted on the security camera.

    The robber that {stole/attempted} the necklace at the museum was spotted on the security camera.

36. The pilot {flew/mastered} the plane after just six lessons but nearly crashed at takeoff.

    The pilot that {flew mastered} the plane after just six lessons nearly crashed at takeoff.

APPENDIX 6: STIMULI USED IN LOWDER AND GORDON (UNDER REVIEW) EXPERIMENT 2

The stimuli from Experiment 2 are shown below in their object-extracted form. Each sentence was also presented as an SRC, as described in the text. Within the brackets, the first verb was used in the Control condition, whereas the second verb was used in the Coercion condition.

1. The memo that the engineer {read/started} outlined the details of the upcoming fundraiser.
2. The soup that the girl {ate/tried} soothed the sick people in the hospital.
3. The memo that the secretary {wrote/began} announced that there would be pay raises for all the employees.
4. The article that the editor {read/finished} revealed that the senator was involved in a big scandal.
5. The house that the architect {designed/finished} included a large porch in the backyard that we all loved.
6. The braid that the stylist {braided/started} reminded me of a new hairstyle I saw in a magazine last week.
7. The kitchen that the designer {designed/began} included several brand new appliances.
8. The newspaper that the editor {edited/finished} received a Pulitzer Prize a couple of years ago.
9. The novel that the publisher {read/began} earned a great deal of money from advance sales.
10. The papers that the student {wrote/tried} received bad grades from several different teachers.
11. The portrait that the critic {criticized/started} illustrated many important techniques to the art students.
12. The gates that the guard {closed/finished} kept troublemakers off the property late at night.
13. The garden that the woman {planted/started} grew beautiful tulips and daffodils every spring.
14. The fields that the farmer {plowed/started} produced corn, beans, and cucumbers later that year.
15. The coffee that the waitress {made/started} greeted the customers as soon as they walked in the diner.
16. The script that the director {read/started} won the award for best screenplay at the film festival.
17. The coffee that the banker {drank/started} remained in the break room all morning.

18. The grades that the teacher {recorded/started} improved tremendously over the course of the semester.
19. The syllabus that the professor {wrote/finished} listed the dates of all the upcoming exams.
20. The convertible that the lawyer {drove/preferred} attracted a lot of attention in the small town.
21. The manuscript that the publisher {read/started} described the current state of our political system.
22. The defendant that the lawyer {defended/endured} made one final plea to the jury.
23. The prescription that the doctor {wrote/began} treats several rare bacterial infections.
24. The taxes that the auditor {audited/began} upset everyone at the firm.
25. The tuxedo that the surfer {wore/endured} looked much better than anyone had anticipated.
26. The velvet that the nurse {wore/preferred} fascinated many of the patients in the hospital.
27. The letter that the child {wrote/began} asked Santa for a shiny new bicycle.
28. The biplane that the pilot {flew/preferred} soared high above the snowy mountains.
29. The article that the journalist {wrote/began} accused the governor of embezzling millions of dollars.
30. The house that the builder {built/started} included a stunning balcony in the master bedroom.
31. The truck that the mechanic {repaired/finished} carried heavy supplies from the shed to the garage.
32. The cake that the dieter {ate/resisted} looked incredibly unhealthy.
33. The novel that the teenager {read/began} recounted terrifying stories of zombies and vampires.
34. The book that the student {read/finished} proved to be a valuable resource in fixing the computer problems.
35. The necklace that the robber {stole/attempted} attracted the attention of all the local media.
36. The plane that the pilot {flew/mastered} glided effortlessly into the bright blue sky.

APPENDIX 7: STIMULI USED IN LOWDER AND GORDON (UNDER REVIEW) EXPERIMENT 3

The stimuli from Experiment 3 are shown below in their pseudocleft form. Each sentence was also presented as a cleft, as described in the text. Within the brackets, the first verb was used in the Control condition, whereas the second verb was used in the Coercion condition.

1. What the engineer {read/started} was the memo for the new employee orientation today.
2. What the girl {ate/tried} was the soup while chatting with friends at the new restaurant.
3. What the secretary {wrote/began} was the memo about the new office policy shortly after being hired.
4. What the editor {read/finished} was the article about tax increases before going home for dinner.
5. What the architect {designed/finished} was the house for the family down the block.
6. What the stylist {braided/started} was the braid in the girl's hair yesterday afternoon.
7. What the designer {designed/began} was the kitchen in the house next door, but she was worried that she wouldn't finish.
8. What the editor {edited/finished} was the newspaper that had to go out early the next morning.
9. What the publisher {read/began} was the novel written by Mark Twain's son.
10. What the student {wrote/tried} was the papers assigned for class, but he did not receive a good grade.
11. What the critic {criticized/started} was the portrait in the gallery, saying that it reminded him of Picasso.
12. What the guard {closed/finished} was the gates on the property before going home for the night.
13. What the woman {planted/started} was the garden as soon as the last winter frost melted away.
14. What the farmer {plowed/started} was the fields on the south side of the property where he hoped to grow corn.
15. What the waitress {made/started} was the coffee as soon as she saw all the customers lined up outside the diner.
16. What the director {read/started} was the script for the action movie that would begin filming next summer.
17. What the banker {drank/started} was the coffee in the break room since he was getting sleepy.

18. What the teacher {recorded/started} was the grades for her class since report cards are going out next week.
19. What the professor {wrote/finished} was the syllabus for his class, but he also needed to write all his lectures.
20. What the lawyer {drove/preferred} was the convertible with the fine leather seats, even though it was expensive.
21. What the publisher {read/started} was the manuscript two days after receiving it from the editor.
22. The one who the lawyer {defended/endured} was the defendant who everyone thought was guilty.
23. What the doctor {wrote/began} was the prescription for the new cold medicine that the child needed.
24. What the auditor {audited/began} was the taxes for the company that had gotten into trouble with the IRS.
25. What the surfer {wore/endured} was the tuxedo even though it made him feel uncomfortable all night long.
26. What the nurse {wore/preferred} was the velvet made in India, but she agreed that it was too expensive.
27. What the child {wrote/began} was the letter for Santa Claus, hoping it would get to him before Christmas.
28. What the pilot {flew/preferred} was the biplane whenever he went on long trips.
29. What the journalist {wrote/began} was the article about the hurricane that had devastated the town.
30. What the builder {built/started} was the house for his family, but he still needed a landscaper to do the yard.
31. What the mechanic {repaired/finished} was the truck several days before he started to work on the car.
32. What the dieter {ate/resisted} was the cake at the birthday party, even though she had eaten carrots all week.
33. What the teenager {read/began} was the novel about vampires, even though he knew if would give him nightmares.
34. What the student {read/finished} was the book about sailing, and she was eager to try out her new skills.
35. What the robber {stole/attempted} was the necklace at the museum, but he was spotted on the security camera.
36. What the pilot {flew/mastered} was the plane after just six lessons, but he nearly crashed at takeoff.

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