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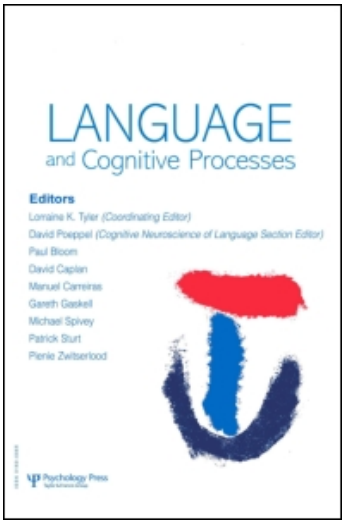

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Comprehension of elided structure: Evidence from sluicing

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Comprehension of elided structure: Evidence from sluicing

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In sluiced sentences like "Nolan colored, but he wouldn't tell me what", the elided clause ("what [Nolan colored _]") contains a gap not present in the antecedent clause ("Nolan colored"). Previous work has shown that interpreting such nonparallel sluiced sentences creates measurable processing difficulty, and these processing costs have been interpreted as evidence for an ellipsis-specific "sprouting" operation. The current study compared sluiced sentences and their nonelided counterparts in a self-paced reading task. Results show that nonparallelism was equally costly for both sluiced and nonelided sentences. This finding suggests that these processing costs are as likely to be due to a violation of parallelism expectations for coordinated structures as to be due to ellipsis-specific operations. For nonelided sentences, moreover, the transitivity biases of individual verbs affected the magnitude of these parallelism costs: verb-specific transitivity biases were a reliable predictor of reading times for the nonelided sentences, though not for the sluiced sentences. Implications for the representation and processing of elided structure and the role of verb-specific transitivity biases are discussed.

Keywords: Sentence processing; Ellipsis; Sluicing; Lexical information.

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INTRODUCTION

The processing of ellipsis sentences has attracted increasing attention in the psycholinguistic literature. While much early work on the topic focused on comprehension of verb-phrase ellipsis (Murphy, 1985; Shapiro & Hestvik, 1995; Tanenhaus & Carlson, 1990; Ward, Sproat, & McKoon, 1991; see also Martin & McElree, 2008; Shapiro, Hestvik, Lesan, & Garcia, 2003), more recent work has examined a wider variety of ellipsis constructions, including gapping (Carlson, 2001, 2002; Carlson, Dickey, & Kennedy, 2005), comparative ellipsis (Carlson, 2002), and sluicing (Carlson, Dickey, Frazier, & Clifton, 2009; Frazier & Clifton, 1998, 2005).

The current study was designed to continue the investigation of processing of sluiced sentences, examples of which are given in (1a–b).

(1) a. Nolan colored something, but he wouldn't tell me what _.
b. Nolan colored, but he wouldn't tell me what _.

To understand a sluiced sentence, the content of the elided clause (represented as an unpronounced gap in (1a–b)) must be recovered based on an antecedent clause. The sentences in (1) would be interpreted as in (2):

(2) a. Nolan colored something$_1$, but he wouldn't tell me what$_1$ [he colored $_1$].
b. Nolan colored, but he wouldn't tell me what$_1$ [he colored $_1$].

As these examples suggest, there are two dependencies in sluiced sentences: an ellipsis dependency, between the elided clause and its antecedent, and a wh-extraction dependency, marked with subscripts in (2a–b). Most current analyses of sluicing claim that it is a case of IP or clausal ellipsis, parallel to VP or predicate ellipsis (Lasnik, 2001; Merchant, 2001; Romero, 1997; cf. Ross, 1969).

Sluiced examples like (1–2b) are particularly interesting because they show partial nonparallelism between an elided clause and its antecedent. In both (2a) and (2b), the elided clause [he colored _] must contain a verb and a trace that is related to the wh-phrase "what". In (2a), the indefinite "something" in the first clause can serve as an explicit antecedent that corresponds to the phonetically null trace (Chung, Ladusaw, & McCloskey, 1995). In (2b), however, there is no such antecedent, even though a trace must be present for the sentence to be well formed.

This nonparallelism has consequences for both psycholinguistic processes and linguistic representations. Previous psycholinguistic work on ellipsis has

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shown that comprehenders "fill in" the structure of the antecedent when interpreting an elided constituent (Shapiro & Hestvik, 1995; Shapiro et al., 2003; Tanenhaus & Carlson, 1990; see also Arregui, Clifton, Frazier, & Moulton, 2006; Frazier & Clifton, 2001). When the structure of the antecedent is not compatible with the structure of the elided constituent, processing difficulty arises. For instance, comprehenders show evidence of processing difficulty when an elided VP is not syntactically parallel to its antecedent (Arregui et al., 2006; Mauner, Tanenhaus, & Carlson, 1995; Tanenhaus & Carlson, 1990). Similarly, there is evidence that syntactic nonparallelism in sluiced sentences like (1b) creates processing difficulties for comprehenders. Frazier and Clifton (1998) found, for example, that readers were slower to read sluiced sentences without an explicit antecedent for the trace (1b) than sluiced sentences with such an antecedent (1a). This effect held whether the fronted wh-element was an argument of the verb ("Nolan colored, but he wouldn't tell me what") or an adjunct ("Nolan colored, but he wouldn't tell me where").

Linguistic analyses of sluicing differ regarding the mechanisms responsible for handling nonparallelism between the antecedent and the sluiced clause in cases like (1b) and in their predictions for how similar the processing of sluiced clauses and their nonelided counterparts should be. Some claim there is an additional sluicing-specific operation of "sprouting" at Logical Form (LF) that creates a trace in the sluiced clause in cases like (1b) (Chung et al., 1995). This account claims that sprouting adds further unpronounced structure to the sentence, an operation that is presumably costly (Frazier & Clifton, 1998). It entails, moreover, that nonparallel sluiced sentences are represented and processed differently from nonparallel sentences without ellipsis: the sluiced sentence involves an added operation that an otherwise similar nonelided sentence does not. In contrast, other accounts argue that the interpretation of nonparallel elided structures is handled by more general principles that govern how deaccented and elided material are interpreted (Merchant, 2001; Romero, 1997). These accounts emphasise the requirement for similarity between elided and antecedent structure, claiming that elided material must be semantically or syntactically parallel with given material elsewhere in the sentence. Violations of these parallelism requirements are presumably also costly (Mauner et al., 1995). However, because there is no additional ellipsis-specific operation, similar processing effects should hold for processing unpronounced nonparallel structures as for nonelided nonparallel structures. Note that while these analyses differ regarding how the conflict in nonparallel sluiced

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sentences is resolved and represented, they agree that nonparallel sluiced sentences should be more difficult than parallel ones.[1]

Frazier and Clifton interpreted the processing costs elicited by nonparallel sluiced sentences as psycholinguistic evidence for Chung et al.'s (1995) LF-sprouting operation: the extra processing costs associated with comprehending sentences like (1b) are due to sprouting, which is responsible for creating a trace where there wasn't one before. However, based on Frazier and Clifton's results, it is unclear whether this cost is specific to ellipsis, as would be expected on an LF-sprouting account, or is instead due to costs associated with nonparallelism between the sluiced clause and the antecedent. Parallelism is potentially important for these structures, for two different kinds of reasons. First, a preference for parallelism is generally operative in language comprehension, particularly in contexts where ellipsis is commonly found. There is ample psycholinguistic evidence that comprehenders anticipate parallelism between conjoined constituents, and that they experience processing difficulty if these parallelism expectations are not met (Carlson, 2002; Frazier, Munn, & Clifton, 2000; Frazier, Taft, Roeper, Clifton, & Ehrlich, 1984; Yoshida & Dickey, 2008). In the sluicing examples above, the antecedent clause is conjoined with the clause which contains the embedded sluiced constituent, and coordinated structures are the most common structures containing ellipsis (Hardt, 1993). Furthermore, there is growing evidence that the parallelism preference in language production and comprehension may overlap with the general phenomenon of syntactic priming, the tendency to reuse syntactic structure (Dubey, Keller, & Sturt, 2008). Speakers are much more likely to use the same syntactic structure for similar elements (such as clauses or noun phrases) appearing in coordinated contexts, and measurably more likely to use the same syntactic structure to encode similar linguistic categories in adjacent (but not conjoined) sentences. This tendency to reuse similar structure may help reinforce comprehenders' preference for parallel structures, even in contexts where the parallel phrases are not directly conjoined with one another (as in the sluicing examples above).

Second, parallelism is grammatically required in ellipsis. Syntactic and/or semantic parallelism must hold between conjoined constituents (Munn, 1993; Williams, 1978), the syntactic context in which ellipsis is most commonly found. Furthermore, as discussed above, there is broad agreement that parallelism requirements are even stronger for ellipsis structures (Fox, 1999;

[1] Still other accounts claim that sluicing does not involve any unpronounced material (e.g., Culicover & Jackendoff, 2005), rather, it involves an unpronounced clausal anaphor or pointer which refers to the antecedent clause. Mismatches between the semantic requirements of the clausal anaphor or pointer and the syntactic form of the antecedent are also presumably costly. These accounts are similar to the sprouting account of Chung et al. (1995) in claiming that the syntactic representation of sluiced clauses is qualitatively different from the representation of otherwise similar nonelided sentences.

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Kehler, 2000). Ellipsis constructions require parallelism between elided constituents and antecedents to be well formed (Hankamer & Sag, 1976; Sag, 1976; see also Kehler, 2000; Merchant, 2001). This parallelism requirement has been formulated in syntactic terms (e.g., Merchant, 2001) as well as semantic or pragmatic ones (e.g., Hardt, 1993; Kehler, 2000), but there is consensus that parallelism is a grammatical requirement for the licensing of ellipsis. Recent work has argued that this parallelism requirement reflects more general constraints on the relationship between phonologically reduced material (including ellipsis as well as deaccented material) and given information in the preceding context (Schwarzchild, 1999; Tancredi, 1992). Both elided and deaccented material must be connected to a presupposed antecedent in the preceding context, and must match that antecedent in terms of their grammatical structure and pragmatic features, such as focus marking (Merchant, 2001; Tancredi, 1992). Failure to match that presupposed antecedent results in unacceptability for both deaccented and elided structure. This grammatical requirement for parallelism likely reinforces the general preference to anticipate parallel structure during language comprehension.

The existing results are thus confounded: they could be equally well explained by processing costs associated with an ellipsis-specific grammatical operation or by a general nonparallelism penalty. Further research is required to disentangle these possibilities. A nonparallelism penalty should apply not only to sluiced sentences, but also to otherwise similar nonelided sentences. Comparing reading times for (1b) (repeated in (3a)) with reading times for its nonelided counterpart (3b) would therefore allow us to determine whether the costs associated with the nonparallel (1b) are due to sprouting (and are specific to ellipsis), or are instead due to a more general penalty for nonparallelism.

(3) a. Nolan colored, but he wouldn't tell me what _.
    b. Nolan colored, but he wouldn't tell me what$_1$ he colored $_{-1}$.

Explaining the disadvantage for nonparallel sluicing sentences in terms of a more general nonparallelism penalty, rather than in terms of an ellipsis-specific operation, seems desirable on both psycholinguistic and theoretical linguistic grounds. From a psycholinguistic standpoint, a parallelism account assimilates the sluicing findings to the more general preference for parallel structures which is operative in the language comprehension system. This preference appears both in conjoined contexts (Frazier et al., 2000) and in nonconjoined contexts (albeit less dramatically in the latter case; Dubey et al., 2008). It also appears to drive anticipatory parsing behaviour (Staub & Clifton, 2006). Being able to explain the sluicing findings in terms of this more general principle thus seems preferable on conceptual grounds.

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From a theoretical linguistic standpoint, a parallelism explanation provides for a simpler account of the facts of ellipsis. Rather than postulating specific grammatical mechanisms to explain ellipsis or sluicing (e.g., Chung et al., 1995), the parallelism account can explain the constraints on elided structures like sluicing in terms of general constraints on conjoined structure (the syntactic environment where ellipsis is most commonly found) and on deaccented structure and the expression of given or presupposed information. As noted above, syntactic and/or semantic parallelism is grammatically enforced in ellipsis sentences, much as it is for conjoined structures. Furthermore, much recent research on ellipsis has focused on the similarities between deaccented and elided material (Merchant, 2001; Sag, 1976; Schwarzchild, 1999; Tancredi, 1992). The two types of reduced material appear to obey similar semantic and pragmatic constraints. Again, being able to explain the penalty observed for nonparallel sluicing sentences in terms of these more general linguistic constraints seems preferable on conceptual grounds.

The study described here was designed to evaluate these competing hypotheses by testing elided and nonelided sentences like those in (3). The study aimed in part to replicate Frazier and Clifton's (1998) primary finding for sluiced sentences: i.e., nonparallel sentences were read more slowly than parallel sentences. It also sought to replicate a secondary finding from Frazier and Clifton: when they manipulated the type of wh-extraction dependency, they found that argument-extracted sentences ("but he wouldn't tell me what") were read more quickly than adjunct-extracted sentences ("but he wouldn't tell me where"). These results demonstrate that readers are faster to comprehend arguments than adjuncts in sluicing, as has been independently shown for nonelided sentences (Boland & Blodgett, 2006; Clifton, Speer, & Abney, 1991). Our stimuli also included this manipulation, with the expectation that sentences with adjunct extractions would be read more slowly than sentences with argument extractions.

Finally, and most significantly, the study investigated whether the same patterns hold for otherwise identical sentences that do not involve ellipsis. Evidence that processing costs are specific to sluiced sentences would be evidence in favour of an LF-sprouting analysis of these facts (Chung et al., 1995). In contrast, evidence that the costs are comparable in sluiced and nonelided sentences would weaken the claim that Frazier and Clifton's (1998) results are due to an ellipsis-specific operation like sprouting. Instead, such a finding would suggest that they are equally likely to be due to a general nonparallelism penalty. This pattern would lend support to linguistic theories that explain the interpretation of ellipsis structures in terms of parallelism requirements between conjoined clauses (Fox, 1995, 1999) or more general requirements on deaccented or unpronounced structures (Merchant, 2001; Romero, 1997; Tancredi, 1992).

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METHODS

Participants

Forty undergraduates recruited from introductory linguistics classes at Northwestern University participated in exchange for course credit. All the participants were native speakers of English with no reported history of speech-language disorders. All participants provided informed consent prior to participation.

Materials and design

Participants read 32 sentences like those in Table 1 in a self-paced moving window format. The pipes (|) in Table 1 indicate presentation segments. The sentences appeared in one of eight conditions, in a $2 \times 2 \times 2$ within-participants design. The first factor was *ellipsis*: the sentences were either *sluiced* sentences (a–d) or their *nonelided* counterparts (e–h). Note that both types of sentences contain traces of the extracted wh-phrase in the second clause; they differ only in whether the trace occurs in an elided clause. The second factor was *extraction type*: the sentences involved either *argument* extractions (c–d, g–h: "what [she typed _]") or *adjunct* extractions (a–b, e–f: "where [she typed _]"). The third factor was *parallelism*: whether the initial clause contained an antecedent for the wh-phrase found in the second clause (*parallel* conditions, a, c; e, g: "The secretary typed something/somewhere") or not (*nonparallel* conditions, b, d; f, h: "The secretary typed quickly"). Conditions (a–d) were replications of Frazier and Clifton's (1998) manipulations of parallelism and argument vs. adjunct extraction. The only difference was that the sluiced sentences contained an adverb (such as "exactly" or "precisely") after the wh-element, to equate the sluiced sentences for length to their nonelided counterparts.

TABLE 1
Sample sentence stimuli by condition

a. The secretary | typed something, | but I don't know | what exactly.	e. The secretary | typed something, | but I don't know | what she typed.
b. The secretary | typed quickly, | but I don't know | what exactly.	f. The secretary | typed quickly, | but I don't know | what she typed.
c. The secretary | typed somewhere, | but I don't know | where exactly.	g. The secretary | typed somewhere, | but I don't know | where she typed.
d. The secretary | typed quickly, | but I don't know | where exactly.	h. The secretary | typed quickly, | but I don't know | where she typed.

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Conditions with no overt antecedent for the wh-phrase were expected to cause processing difficulty. These conditions are highlighted in grey in Table 1. Evidence of ellipsis-specific processing costs (i.e., a sprouting operation) should appear as a significant interaction of ellipsis and parallelism: the difference between parallel and nonparallel conditions should be larger in sluiced than in nonelided sentences. In contrast, a general nonparallelism penalty would be reflected by a main effect of parallelism that does not interact with ellipsis, with slower reading times for nonparallel conditions (b, d, f, h) than for parallel conditions (a, c, e, g).

The experimental sentences were mixed in among 52 unrelated filler sentences of various types, including comparative sentences, multi-clause which-NP questions, and sentences with adjunct clauses. Approximately half the experimental and filler sentences were followed by a comprehension question.

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Procedure

Participants read the experimental and filler sentences in a self-paced reading task, presented on a PC using the PCEXPT experiment-running suite by Charles Clifton. Sentences were presented in a noncumulative moving-window format. Each sentence was preceded by a preview of underscores indicating where the characters of the sentence would appear. Participants pressed either of two marked buttons on the keyboard (D, K) to reveal the presentation segments and advance through the sentence. At the end of each sentence, the sentence disappeared from the screen to be replaced with either the preview of another sentence or a comprehension question regarding the sentence just read. Each comprehension question had two answers below it. Participants pressed the left button (D) to indicate that they wanted to choose the left-hand answer, and the right button (K) to indicate the right-hand answer.

RESULTS

Analyses of variance

Reading times of less than 200 ms or more than 4,000 ms for a segment were discarded. Mean reading times per presentation segment averaging over items and participants are reported in Table 2.

The critical segment is the final one, containing either the sluice (“what, exactly”) or its nonelided counterpart (“what she typed”). Mean reading times for this segment are given in Table 3, with means for nonparallel conditions highlighted in grey.

TABLE 2
Reading times for each presentation segment in milliseconds by condition

	Segment 1	*Segment 2*	*Segment 3*	*Segment 4*
Sluiced, argument wh-extraction, parallel	729	877	926	831
Sluiced, argument wh-extraction, nonparallel	758	1,062	1,006	918
Sluiced, adjunct wh-extraction, parallel	759	1,104	971	910
Sluiced, adjunct wh-extraction, nonparallel	782	1,047	1,093	1,018
Nonelided, argument wh-extraction, parallel	724	854	919	737
Nonelided, argument wh-extraction, nonparallel	786	1,096	997	795
Nonelided, adjunct wh-extraction, parallel	735	1,099	1,022	859
Nonelided, adjunct wh-extraction, nonparallel	754	1,068	1,025	932

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Multivariate analyses of variance were carried out on the mean reading times for each segment, with ellipsis (sluiced vs. nonelided), extraction type (argument vs. adjunct), and parallelism (parallel vs. nonparallel) as factors. Separate ANOVAs were carried out on participant (F_1) and item (F_2) means.

Analyses of reading times for the first three segments revealed no reliable main effects or interactions (all F_1, $F_2 < 2$). Analyses for the final segment revealed a main effect of *parallelism*: participants were slower to read this segment when the first clause did not contain an overt antecedent for the wh-phrase (cells highlighted in grey in Tables 1 and 3: $F_1[1, 39] = 10.25$, $p < .01$; $F_2[1, 31] = 4.60$, $p < .05$). This reading-time penalty replicates Frazier and Clifton's results. There was also a main effect of *extraction type*: the final segment was read faster when it contained an argument extraction than when it contained an adjunct extraction ($F_1 = 23.01$, $p < .001$; $F_2 = 8.47$, $p < .01$). This is, again, a replication of Frazier and Clifton's results, and it is also consistent with previous work showing a reading-time advantage for arguments over adjuncts (Boland & Blodgett, 2006; Clifton et al., 1991). In addition to these replications, moreover, our data show a main effect of *ellipsis*, with sluiced sentences being read more slowly than their nonelided counterparts ($F_1 = 11.38$, $p < .01$; $F_2 = 5.25$, $p < .05$). This main effect

TABLE 3
Reading times for final segment in milliseconds by condition

	Sluiced	*Nonelided*
Argument wh-extraction, parallel	831	737
Argument wh-extraction, nonparallel	918	795
Adjunct wh-extraction, parallel	910	859
Adjunct wh-extraction, nonparallel	1,018	932

suggests that readers were aided by encountering overt versions of the material associated with the extraction.

There were no significant interactions (all F_1, $F_2 < 2$). In particular, there was no evidence of an interaction of ellipsis (sluiced vs. nonelided) and parallelism (parallel vs. nonparallel). This finding casts doubt on the hypothesis that observed processing difficulties were due to an ellipsis-specific processing cost like sprouting. In addition, there was no evidence of an interaction of parallelism and extraction type (argument vs. adjunct). This suggests that there was no special advantage for more-predictable arguments in the absence of an overt antecedent for the trace (though see Hirotani, 2003, for evidence that the argument advantage for sluiced sentences may be reduced or eliminated in context). This also replicates Frazier and Clifton's failure to find an interaction between wh-extraction type and antecedent.

Regression analyses

The main effect of ellipsis indicates that encountering overt material in the second clause helped readers to resolve the wh-extraction dependency. Across conditions, the second clause always contained a wh-element that had to be associated with a postverbal trace, and readers were faster to make this association if they encountered an overt version of the structure. This finding is consistent with previous findings suggesting that encountering a verb's surface form (even very briefly) may facilitate activation of a dispreferred structural analysis, if the verb is biased towards occurring in that syntactic context (Kim, Srinivas, & Trueswell, 2002; Trueswell & Kim, 1998). Encountering overt lexical material can facilitate syntactic processing, particularly if the required syntactic analysis is dispreferred or unexpected.

To further examine the source of the processing advantage observed in the nonelided conditions in this study, post-hoc regression analyses were carried out on reading times for the final segment. These reading times were correlated with estimates of the transitivity biases of the verbs. The transitivity biases were obtained from a large corpus of English verbs and the syntactic frames they occur in, based on half the British National Corpus, approximately 50 million words (Schulte im Walde, 1998). Since a bias for transitivity should only facilitate the activation of transitive frames and the resolution of argument wh-extraction dependencies, the regression analyses were carried out only on conditions with wh-extractions involving arguments (Table 1, sentences a–b, e–f).

Transitivity biases for each verb were calculated by dividing the number of times the verb occurred in a transitive syntactic frame [V NP] by that number of occurrences plus the number of times the verb occurred in an intransitive syntactic frame [V]. Transitivity biases were not calculated for two verbs, "weld" and "vacuum", because they had fewer than 10 occurrences in the

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corpus. Verbs that frequently occur in a transitive frame were expected to show a reading-time advantage over verbs that do not because the fronted wh-phrase requires activation of a transitive structure.

In the regression analysis, transitivity bias was found to be a reliable predictor of reading time only for nonelided sentences with nonparallel antecedents like sentence (f) in Table 1, "The secretary typed quickly, but I don't know what she typed" ($F[1, 29] = 4.57$, $p < .05$). Reading times were negatively correlated with transitivity bias for this condition ($r = -.374$): sentences with high-bias verbs were read more quickly at this segment than sentences with low-bias verbs. This result is in line with the prediction that verbs that occur frequently in a transitive frame should show an advantage when unexpected activation of that frame is required, as in nonparallel conditions. Transitivity bias was not a reliable predictor for either of the parallel conditions (Table 1, sentences a, e), which did not require activation of an unexpected transitive frame (a: $F[1, 29] = 0.96$, e: $F[1, 29] = 0.01$). In these conditions, the overt antecedent of the trace ("The secretary typed something") entails that the transitive syntactic frame has already been activated for the verb.

Surprisingly, transitivity bias was also not a reliable predictor of reading times for the nonparallel sluiced condition (Table 1, sentence b), "The secretary typed quickly, but I don't know what exactly", even though this condition also required activation of an unexpected transitive frame ($F[1, 29] = 1.13$). Reading times in this condition were less strongly negatively correlated with transitivity bias ($r = -.181$).

DISCUSSION

There are four results worth highlighting for what they suggest about readers' analysis (and reanalysis) of the second clause in our stimulus sentences, which always contained a wh-extraction of some type. First, both of the main effects of parallelism and wh-extraction type that Frazier and Clifton (1998) identified (as well as the absence of an interaction between these factors) were found in the current study as well. This pattern suggests that the stimuli used in the current study had the same relevant properties as the stimuli in Frazier and Clifton's study (despite minor changes). It also provides additional empirical evidence that interpreting elided clauses that have no structurally parallel antecedent is costly, not only in VP-ellipsis contexts (Arregui et al., 2006; Tanenhaus & Carlson, 1990), but also in sluicing. This finding is consistent with linguistic theories that require syntactic parallelism between an elided clause and its antecedent (e.g., Sag, 1976).

Second, there was no evidence of a larger nonparallelism penalty for sluiced sentences than for nonelided sentences. Specifically, there was no

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interaction between ellipsis and parallelism. The current results thus provide no evidence for an ellipsis-specific sprouting operation. Instead, they seem more consistent with an account of Frazier and Clifton's (1998) results that relies on a more general processing penalty for nonparallelism. Assuming that the magnitude of the processing costs is indeed comparable in the sluiced and nonelided conditions, as the absence of an interaction suggests, this result would appear to be more compatible with approaches in which no special grammatical operations are required in sluicing (Merchant, 2001; Romero, 1997). Minimally, the similarity of the patterns in the sluiced and corresponding nonelided conditions in the current study weakens the psycholinguistic case that an ellipsis-specific mechanism (like Chung et al.'s (1995) LF-sprouting operation) is required to resolve the conflict in nonparallel sluiced sentences like (1b).

Third, there was no interaction between ellipsis and wh-extraction type. This suggests that the processing disadvantage for adjuncts was similar regardless of whether the structure was overt or unpronounced. This finding suggests that the same sorts of parsing preferences and operations hold for elided sentences as for sentences with overt lexical material. These parallel findings for sluiced and nonelided sentences are also somewhat surprising under linguistic analyses that claim that sluiced sentences involve structural operations different from those involved in nonelided sentences (e.g., Chung et al., 1995) or involve no structure at all (e.g., Culicover & Jackendoff, 2005; Ginzburg & Sag, 2000).

Finally, there was a main effect of ellipsis, with sluiced sentences being read more slowly than their nonelided counterparts. There are two possible explanations for this finding which are related to the issues explored here. One is that the parallelism requirements are stricter in the case of ellipsis, since parallelism is not only generally preferred in ellipsis, but also grammatically required (e.g., Fox, 1999; Kehler, 2000; Merchant, 2001; Tancredi, 1992). This stricter requirement created a larger penalty for the nonparallel sluiced sentences than for their nonelided counterparts. However, this explanation would predict an interaction of parallelism and ellipsis, which was not found in the current study. Alternatively, as suggested by the results of the regression analysis, this finding may instead reflect a processing advantage for the nonelided sentences, such that overt material assisted readers with the computation of an unexpected syntactic structure. The post-hoc regression analyses provide evidence for this latter explanation. Reading times were faster in the nonparallel condition when participants encountered a verb that was strongly transitively biased. This result is consistent with previous work demonstrating that seeing (or hearing) a strongly biased verb, even briefly, can facilitate activation of a dispreferred syntactic analysis (Kim et al., 2002; Trueswell & Kim, 1998). However, this explanation would also appear to predict an interaction of parallelism and ellipsis, again not found in the

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current study. Further work is needed to replicate the main effect of ellipsis, and to see which (if either) of these explanations is correct. An interaction of parallelism and ellipsis would strengthen the case for either of these explanations.

Regardless of the ultimate explanation of the main effect of ellipsis found here, the disadvantage for sluicing sentences does bear further comment, in particular with respect to the linguistic representation of elided structure. As noted above, much research has drawn attention to similarities between deaccenting and ellipsis. In both cases, linguistic material is phonologically reduced when the information it conveys is available in or inferable from preceding context (Rooth, 1985; Schwarzchild, 1999; Tancredi, 1992). In some sense, deaccenting or ellipsis is licensed in these contexts because the reduced material is redundant. Failing to use the more reduced forms when the full forms would be redundant has been shown to cause a processing penalty in other cases: for example, in the repeated-name penalty found for using a full form (such as a proper name or a definite description) where a pronoun would be equally possible (Gordon, Grosz, & Gilliom, 1993). Interestingly, the findings from the current study suggest any penalties associated with repeating the full form where ellipsis is possible may be outweighed by the processing advantages derived from encountering that overt material. The desire to maximise presuppositions or to avoid repeating given information (e.g., Schwarzchild, 1999) appears to be offset in this case, at least in terms of real-time processing.[2]

The weaker effect of transitivity biases in the sluiced sentences also bears further comment. This finding suggests that there may be an interesting bound on the influence of lexical-bias effects on syntactic processing (Trueswell, 1996;

[2] A reviewer raises the question of whether readers may have been assigning implicit prosody to nonelided conditions, which is consistent with a deaccented reading of these sentences. If readers did indeed assign such an implicit prosody to the nonelided condition, that would undercut the strength of the sluicing vs. nonelided comparison, since ellipsis and deaccenting are subject to similar semantic and pragmatic constraints (cf. Merchant, 2001; Schwarzchild, 1999; Tancredi, 1992). There is significant evidence suggesting that comprehenders assign implicit prosodic contours to sentences during silent reading (see Fodor, 1998, among many others), and some readers may have implicitly deaccented the relevant material in the nonelided sentences. However, such implicit deaccenting would seem to work against the observed main effect of ellipsis. If readers did implicitly deaccent the material following *what*, that deaccenting should have made the nonelided condition more similar to the elided condition and thus should have reduced the difference between the elided and nonelided conditions. To the extent that the main effect of ellipsis is a reliable one, it provides suggestive evidence that readers did not engage in much implicit deaccenting, or that the effect of such deaccenting was not sufficient to obscure the (other) differences between the conditions. Nonetheless, it would be preferable to be able to establish that readers did not implicitly deaccent the material in the nonelided condition, for instance in a follow-up study with stimuli presented auditorily and a direct manipulation of prosody. We are grateful to the reviewer for this point.

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Trueswell & Kim, 1998) such that perceivers must encounter a verb's surface form to benefit from information regarding its co-occurrence frequencies. Failing to encounter the verb's surface form, as in ellipsis contexts, cuts out (much of) this lexical-bias information. See also Shapiro et al. (2003) for results suggesting that listeners are (temporarily) insensitive to lexically specific information (such as the noncompositional meaning of idiomatic expressions like "lose his grip") in ellipsis contexts.

CONCLUSION

The current study replicated Frazier and Clifton's (1998) results for sluiced sentences, showing that interpreting nonparallel sluiced sentences creates measurable processing difficulty. However, we found similar penalties for corresponding examples without ellipsis, suggesting that similar operations must take place in both sluiced and nonelided sentences. This result favours linguistic analyses in which sluicing does not require special sluicing-specific operations (cf. Chung et al., 1995). The complementary results from sluiced and nonelided sentences also support linguistic analyses in which the resolution of ellipsis dependencies (whether in VP ellipsis or sluicing) requires syntactic parallelism between the elided clause and its antecedent. Furthermore, they suggest that unpronounced structure found in ellipsis is processed similar to overt structure. However, the main effect of ellipsis and the results of the regression analyses also suggest that having to (re)build structure without overtly pronounced lexical items may have its own penalties for readers, depriving them of information of which they might otherwise take advantage.

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