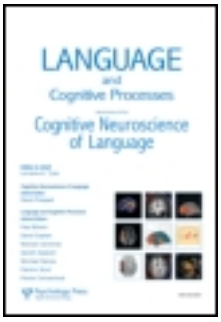

Language and Cognitive Processes
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/plcp20

Predictive processing of syntactic structure: Sluicing and ellipsis in real-time sentence processing

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Available online: 05 Mar 2012

To cite this article: Masaya Yoshida, Michael Walsh Dickey & Patrick Sturt (2012): Predictive processing of syntactic structure: Sluicing and ellipsis in real-time sentence processing, Language and Cognitive Processes, DOI:10.1080/01690965.2011.622905

To link to this article: http://dx.doi.org/10.1080/01690965.2011.622905

LANGUAGE AND COGNITIVE PROCESSES 2012, iFirst 1–31

Psychology Press
Taylor & Francis Group

Predictive processing of syntactic structure: Sluicing and ellipsis in real-time sentence processing

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This paper investigates the prediction of syntactic structure during sentence processing, using constructions that temporarily allow a sluicing interpretation in English. Making use of two well-known properties of sluicing and pronoun interpretation—connectivity effects and the local antecedent requirement on reflexives, respectively—we show that (1) the parser chooses a sluicing structure over other possible structures when sluicing is a possibility, and (2) the structure which the parser posits for sluicing involves detailed hierarchical syntactic structure. A self-paced reading experiment and three offline experiments (two acceptability rating studies and a sentence completion study) find evidence that readers immediately try to associate a reflexive pronoun embedded inside a wh-phrase with a potential antecedent in the preceding clause. However, this association is made only if a sluicing structure is a possible continuation of the sentence. This finding suggests that readers actively anticipated a sluicing structure when it was grammatically permissible, and that this structure is sufficiently detailed to license reflexive binding. This result adds to the increasing evidence that comprehenders make detailed predictions regarding upcoming linguistic structure.

Keywords: Sluicing; Ellipsis; Prediction; Gender mismatch effects.

An increasing number of studies indicate that listeners and readers make detailed predictions regarding upcoming material during language comprehension. Based on the words and phrases they have heard, they generate hypotheses about what is likely

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We are most grateful to the three anonymous reviewers for their valuable comments and suggestions. We would also like to thank Diogo Almeida, Kiel Christianson, Fernanda Ferreira, Janet Fodor, Lyn Frazier, Tomohiro Fujii, Susan Garnsey, Takuya Goro, John Hale, Ken Hiraiwa, Scott Jackson, Chris Kennedy, Masatoshi Koizumi, Howard Lasnik, Jason Merchant, Alan Munn, Yukio Otsu, Colin Phillips, Martin Pickering, Hiromu Sakai, Tetsuya Sano, Ming Xiang, for their valuable discussions, comments and criticisms. This work is supported in part by an ESRC postdoctoral fellowship (PTA-026-27-1379) to Masaya Yoshida.

http://www.psypress.com/lcp http://dx.doi.org/10.1080/01690965.2011.622905

to follow. For example, event-related potential (ERP) work by Federmeier and colleagues (Federmeier & Kutas, 1999; Meyer & Federmeier, 2007; Wlotko & Federmeier, 2007) has suggested that comprehenders anticipate the semantic features of upcoming words based on material they have already encountered in the sentence. Participants exhibit reduced N400 responses to incoming words if those words are semantically related to or are predictable based on the preceding sentence (e.g., Wlotko & Federmeier, 2007). Other ERP work has shown effects that are consistent with the prediction of morphosyntactic (Van Berkum et al., 2005) or phonological (DeLong, Urbach, & Kutas, 2005) features of an upcoming predicted word. Similarly, visual world studies found that when listeners encounter a transitive verb like *eat*, they show anticipatory eye movements to appropriate objects (something edible) in the visual scene, even before words describing the objects are actually uttered (Altmann & Kamide, 1999). (See also Kamide, Altmann, and Haywood, 2003, and Kamide, Scheepers, and Altmann, 2003, for additional visual-world evidence of predictive eye-movements based on the verb and other material in the sentence.)

Such anticipatory or predictive sentence processing is also suggested in the domain of structure building processes. Staub and Clifton Jr (2006), examining sentences containing *either-or*, found that readers not only anticipated an upcoming *or* after reading *either*, but also generated expectations about the material following *or*. They found that reading was facilitated when material following *or* was of the same syntactic category (clause or noun phrase) as the material bracketed by *or* and *either*. Both these results indicate that readers generate detailed expectations regarding upcoming material, based on the bottom-up input they have encountered thus far and the possible grammatical relationships between that input and yet-to-be encountered material.

Phillips (2006) and Wagers and Philips (2009) also make a similar point. They suggest that the parser builds upcoming structure via an interaction of the available bottom-up information and the deployment of grammatical constraints on long-distance dependencies. Phillips (2006), for example, suggested that the parser constructs a fully fledged upcoming clausal structure upon encountering a complex subject noun phrase that contains a parasitic gap. In parasitic gap constructions, a wh-filler is linked to two gaps. Typically, one is in an island and the other is in the main clause. A unique property of parasitic gap constructions is that the gap in the island (the parasitic gap) must be licensed by the gap in the main clause (the licensing gap) under certain structural conditions. Phillips (2006) examines the subject parasitic gap constructions as in (1), in which the parasitic gap ($\_\__{pg}$) is located in a complex subject noun phrase (NP) and the licensing gap is in the verb phrase (VP) that follows the subject NP. As the contrast in (1) indicates, a parasitic gap in the subject NP can be licensed only when the subject NP involves an infinitival clause.

(1) a. The school superintendent learned <u>which schools</u> [$_{\text{SubjectNP}}$ the proposal to expand $\_\__{pg}$ upon the current curriculum] would overburden $\_\_$ during the following semester.
b. *The school superintendent learned <u>which schools</u> [$_{\text{SubjectNP}}$ the proposal that expanded $\_\__{pg}$ upon the current curriculum] would overburden $\_\_$ during the following semester.

A problem of this type of construction for incremental parsing is whether the parser can posit a gap in the Subject NP or not. When the parser is processing the subject NP, the parser cannot tell whether there will be a gap in the main clause that can license the gap in the subject clause or not. If a gap is posited inside the subject NP and there is

not a licensing gap in the main clause, it will result in a subject island violation and the parser will be trapped into building an ungrammatical structure as in (2). On the other hand, if there is a licensing gap in the main clause downstream, then positing a gap does not cause an island violation.

(2) *The school superintendent learned which schools [$_{\text{SubjectNP}}$ the proposal to expand__upon the current curriculum] would overburden the teachers during the following semester.

What Phillips found is that the parser posits a gap in the subject clause only when the posited gap can potentially be licensed as a parasitic gap by another gap that will come in the later part of the sentence. Making use of plausibility effects (see Traxler & Pickering, 1996, among others) as a probe for the parser's positing of a gap, Phillips observed that readers were slower to read the verb *expand* in the sentence *The school superintendent learned which students the proposal to expand*... than in the sentence *The school superintendent learned which students the proposal that expanded*... relative to plausible control conditions. This contrast strongly suggests that the parser posits a gap in the subject NP when it involves an infinitival clause, that is, when a parasitic gap can be licensed, but not when the subject NP involves a finite clause, that is, when a parasitic gap is ungrammatical. This in turn strongly suggests that, at the point of subject NP, the parser pre-computes at least some aspects of the structure of the upcoming clause in order to decide whether a parasitic gap can be licensed in the subject NP or not. It posits an upcoming but as-yet-unencountered long-distance dependency that would allow *which students* to be associated with *the proposal to expand*, but not with *the proposal that expanded*. Phillips argues that such structure building is driven by the licensing requirements of parasitic gaps, which crucially require the presence of a specific type of syntactic structure.

Additional evidence that the parser actively anticipates upcoming structure comes from an ERP study by Lau, Stroud, Plesch and Phillips (2006). Lau and colleagues presented readers with sentences where a possessive-marked noun (*Dana's*) was followed by a preposition (*of*), which created a local syntactic violation. Previous ERP work (Friederici, Pfeifer, & Hahne, 1993; Hahne & Friederici, 1993; Neville, Nichol, Barss, Forster, & Garrett, 1991) has found that such violations elicit a fast-emerging anterior negativity. Lau and colleagues found that this ERP response was attenuated when the preceding sentence allowed readers to predict that the possessive noun signalled noun-phrase ellipsis, as in *Although the bridesmaid kissed Mary's mother, she did not kiss Dana's (of the bride)*. While this sentence is ungrammatical, it elicited a much-reduced anterior negativity at the position of *Dana's*, since the presence of NP ellipsis following *Dana's* is predictable given the possessive NP *Mary's mother*. This finding suggests that readers actively anticipated an ellipsis structure at the position where it was licensed, based on material in the preceding sentence.

All of these studies suggest that the human parser is equipped with some mechanism that can make use of available lexical and syntactic information to set certain predictions about the upcoming lexical items or syntactic structure. In this study we aim to provide further support for the claim that the parser is equipped with such a predictive mechanism, through an experimental study of Sluicing constructions, as in (3).

(3) John told some stories, but we couldn't remember which stories.

Sluicing is an ellipsis structure, as were the structures investigated by Lau et al. (2006). The current paper reports an online self-paced reading experiment (supplemented by three offline experiments) that show the following points. First, the parser can project hierarchical syntactic structure upon encountering a wh-phrase which is potentially compatible with an upcoming but as yet unencountered sluicing structure. Second, such structure building is initiated at the point of the wh-phrase, where the first clear indication of upcoming ellipsis or overt clausal structure is available. Therefore, we suggest that the parser can predictively construct hierarchical structure in advance of any lexical content confirming ellipsis or hierarchical clausal structure.

Sluicing is a construction that involves a wh-question and the omission of a clause (Ross, 1969). A typical example is (3), above. The whole clause after the wh-phrase is missing in sluicing. The content of the missing part, the ellipsis, must be recovered by readers/listeners or the sentence cannot be interpreted. Therefore, there must be a process that "fills in" appropriate content. Sluicing thus raises interesting questions for both theoretical linguistics and psycholinguistics. A central question in the study of sluicing in theoretical linguistics is how the omitted portion of the sentence gets an appropriate interpretation, that is, what is the nature of the "filling in" process, and what are the constraints on this process (the so-called "recoverability conditions" (see Chomsky, 1964, among many others)). In an example like (3), the material to be recovered comes from the first clause, *John told some stories*. This clause is called the antecedent clause. A long-standing debate in the study of ellipsis is concerned with what representation is associated with the ellipsis which supports the appropriate interpretation (Chung, Ladusaw, & McCloskey, 1995; Dalrymple, Shieber, & Pereira, 1991; Hardt, 1993, 1999; Lasnik, 2001, 2005; Merchant, 2001; Romero, 1998; Ross, 1969; Shieber, Pereira, & Dalrymple, 1999, among others).

A parallel question can be asked from the perspective of real-time sentence processing, namely whether syntactic structure is employed in the processing of ellipsis (Frazier & Clifton Jr, 1998, 2000, 2005). Even though this question has been intensively addressed in theoretical linguistics, relatively little work has considered whether perceivers compute syntactic structure during online processing of ellipsis (viz, Frazier & Clifton Jr, 2000; Martin & McElree, 2008; Murphy, 1985; Tanenhaus, Carlson, & Seidenberg, 1985). Given this state of affairs, one of the main objectives of the present study is to provide evidence regarding whether the parser "fills in" syntactic structure in sluicing (Frazier & Clifton Jr, 1998).

From the perspective of online parsing, there are other interesting questions. One of them is concerned with the problem of ambiguity resolution, namely, whether the parser licenses ellipsis when both ellipsis and nonellipsis are possible structures. In other words, does the parser initially prefer a sluicing structure, in cases where sluicing is possible? Or does it instead prefer a full clausal continuation, without ellipsis? As the following example shows, the same embedded wh-question as in (3) can be followed by nonelliptical structure.

(4) John told some stories, but we couldn't remember *which story* Mary was so impressed with.

Examples like (3) and (4) indicate that the parser faces ambiguity at the point of the wh-phrase (*which story*): The sentence can potentially end at the wh-phrase as in (3) or it can be continued with a full subordinate clause as in (4). Thus, there arises a familiar ambiguity resolution problem. By examining the processing of these sentences, we can investigate what the parser's initial preferences are when both sluicing and other

structures are both possible. Answering this question is our second objective in this study.

This study also addresses the problem of structure building. Specifically, we address the question of the extent to which the parser builds structure that goes beyond the information available from the bottom-up input. Recent studies suggest that, upon encountering a word, the parser constructs hypotheses about what structure is likely to follow (e.g., Altmann & Kamide, 1999; Kamide, Altmann, & Haywood, 2003; Kamide, Scheepers, & Altmann, 2003; Kimball, 1975; Phillips, 2006; Staub & Clifton Jr, 2006; Wagers & Phillips, 2009, among others). In this respect, sluicing constructions provide us with a potential testing ground for the extent to which comprehenders actively project structure in advance of bottom-up input. As discussed above, during the processing of sluicing sentences, the parser faces the ambiguity of a sluicing versus a nonsluicing structure at the point of the wh-phrase. If comprehenders prefer the ellipsis analysis at this point, this choice means that the parser builds a representation of ellipsis in advance of the decisive bottom-up information that can signal the presence of the ellipsis structure. Because such structure of ellipsis cannot be inferred directly with a wh-phrase, the parser should be able to use extra-lexical information to predict the upcoming structure. Alternatively, if comprehenders are driven by bottom-up information, it is possible that the parser would not construct anything other than the minimal structure associated with the wh-NP at the point of wh-phrase. Readers' behaviour when encountering the wh-phrase in potential sluicing sentences can, therefore, tell us how much structure the parser is willing to build in advance of bottom-up input.

Below, we report the results from an online self-paced reading experiment and three offline experiments suggesting that there is hierarchical structure in ellipsis, and that the parser appeals to the sluicing structure as its first choice. Our findings suggest that the parser builds full-fledged hierarchical sentence structure in the position of ellipsis, and this challenges current theories of structure building. Specifically, our findings suggest that the parser is able to build the structural skeleton of the sentence in advance of the bottom-up information that confirms such structure, and theories of structure building in the literature (e.g., left-corner parsers which have a top-down prediction component (Abney & Johnson, 1991; Babyonyshev & Gibson, 1995; Gibson, 1991; Johnson-Laird, 1983; Resnick, 1992; Stabler, 1994, among others) are not sufficiently powerful to handle such large-scale predictive structure building. We will also discuss the possible rationale behind this preference.

SLUICING AND THE TIME COURSE OF SENTENCE PROCESSING

There are two properties of sluicing that are crucially relevant to our experiments. The first concerns the licensing conditions on sluicing. As we have noted, the content of the ellipsis in sluicing is recovered from the antecedent clause. In other words, the ellipsis in sluicing requires an explicit antecedent. Many have observed that the antecedent and the ellipsis must be parallel. Although there have been competing proposals regarding how to formulate this parallelism requirement (viz, Merchant, 2001), for our discussion it is sufficient to point out that the parallelism requirement is not satisfied in examples of sluicing like (5b).

(5) John told some stories, but we couldn't remember
  a. which stories.
  b. *with which stories.

Example (5a) contains a simple wh-NP. In this case, filling in the content of the ellipsis based on the antecedent creates an appropriate interpretation (*which story John told*). On the other hand, in (5b) the wh-phrase is accompanied by a preposition. In this case, filling in the ellipsis using the content of the antecedent clause gives rise to an ungrammatical structure (**with which story John told*), because it violates the selectional restriction of the verb, *told*. *Told* does not take a complement headed by *with* (viz., Merchant, 2001). Examples like (5b) indicate that the ellipsis and its antecedent must be parallel in terms of the content of the clauses. In the case of (5) the selectional restriction of the verb must be parallel both in the ellipsis and the antecedent. In other words, they must share the same verb. Note that an example like (5b) can be grammatical in the nonsluicing context if the continuation contains an appropriate verb following the wh-phrase (as in "John told some stories, but we couldn't remember with which stories John shocked the audience"). Importantly, however, the string in (5b) is not grammatical in the sluicing context.

The second property of sluicing is related to the interaction of sluicing and anaphor resolution. Like other clausal ellipses, sluicing can license a reflexive anaphor which is not acceptable in corresponding nonelliptical structures, the so-called anaphor connectivity effect (Merchant, 2004; Stjepanovic, 2008). Consider the following set of examples.[1]

(6) John told some stories, but I don't know
  a. which stories about himself.
  b. *which stories about himself Mary was so impressed with.
  c. which stories about himself Bill was so impressed with.

Example (6a) has a binding dependency between the reflexive *himself* and its antecedent *John*.[2] However, such a binding dependency cannot be established in (6b). The unacceptability of an example like (6b) suggests that the reflexive in this context cannot be directly associated with an NP in the first clause. In (6c), the reflexive is associated with the subject of the second clause, but it also cannot be associated with the subject of the first clause: (6c) cannot mean that *Bill was impressed with stories about John*. Given that the reflexives in (6b, c) cannot be directly associated with the subject in the first clause, the question is how the association of the reflexive and the subject in the first clause in (6a) is possible.

This puzzle can be easily resolved if we assume that there is a fully fledged syntactic structure underlying the ellipsis, which is parallel to the antecedent clause (Chung, Ladusaw, & McCloskey, 1995; Kennedy, 2003; Lasnik, 2001; Merchant, 2001; Romero, 1998, among others). Under this assumption, example (6a) has the following representation.[3]

[1] The underscores indicate coreference relations.

[2] An anonymous reviewer points out that the reflexives in these sentences are most naturally produced with a pitch accent. This fact suggests that these sentences have some properties of so-called 'contrast sluicing' sentences, discussed by Romero (1998) among others. An example of contrast sluicing is "She knows the guy has five *dogs*, but I don't know how many *cats*." These examples are also acceptable only with focal stress falling on the contrastive NP, 'cats' in this example. Contrastive sluicing sentences exhibit the same sensitivity to syntactic constraints that other sluicing sentences do. Because this experiment did not specifically manipulate the presence of such prosody, and readers covertly assign felicitous prosody to written materials (Fodor, 1998), we will not discuss this interesting contrast further here.

[3] The elided parts are indicated by the strike through —.

(7) . . . which stories about himself [~~John told~~].

This representation is basically the same as the structure of (6c), where the reflexive has a clause-mate antecedent. However, the content of the ellipsis has been filled in from the antecedent clause. If sluicing has the structure in (7), the reflexive can straightforwardly be associated with a nonclause-mate antecedent: sluicing involves exactly the same clause as the antecedent clause, filled in at the ellipsis site. This unpronounced but syntactically present clause contains the real antecedent of the reflexive.

Adopting a well-established generalisation regarding the processing of reflexives, these two properties of sluicing allow us to generate interesting predictions regarding the time course of sluicing comprehension. Recent experimental work on the processing of reflexive anaphors shows that an antecedent is sought immediately when a reflexive is encountered in the input. If the potential antecedent does not match the reflexive's gender, a disruption arises (Sturt, 2003). The resulting reading-time slowdown, the so-called gender mismatch effect (GMME), is also found in studies on the processing of pronouns, both where the pronoun follows the antecedent and when it precedes it (e.g., Badecker & Straub, 2002; Kazanina, Lau, Lieberman, Yoshida, & Phillips, 2007; Sturt, 2003; van Gompel & Liversedge, 2003). Importantly, the GMME respects grammatical constraints on coreference, as specified by Binding theory (Chomsky, 1981). In measures of initial processing, the processing difficulty related to the gender mismatch appears only if a coreference relationship between the anaphor and the potential antecedent is grammatically permissible. Thus, in a self-paced reading study, Kazanina et al. (2007) showed an early mismatch cost for cataphoric pronouns only where the antecedent following the pronoun was licit in terms of Principle C of Binding theory. Moreover, Sturt (2003) showed a mismatch cost for reflexives only when the potential antecedent was licit in terms of Principle A. However, some studies have shown that grammatically illicit antecedents that *match* the anaphor in gender can cause competition effects. Specifically, the presence of two gender-matching potential antecedents can cause a slow-down in reading time when one of them is not a grammatically possible antecedent, as has been found by Badecker and Straub (2002) for both reflexives and pronouns (subject to Principles A and B, respectively).[4] Competition can also lead to increased looks to a grammatically illicit competitor referent in a visual world paradigm, as has been shown for reflexives and pronouns in representational nominal contexts by Runner, Sussman and Tanenhaus (2003). In the study reported below, we use a gender-mismatch manipulation using reflexives, similar to that of Sturt (2003), and we do not consider conditions where multiple gender-matching could potentially lead to competition effects. Thus, we assume that grammatically licensed binding would lead to a reading-time slowdown where the gender of a reflexive mismatched that of its antecedent, but that this effect should be blocked when binding is not grammatically permissible.[5]

The presence or absence of a GMME in sluicing sentences with reflexives like (6a–c) can, therefore, tell us if and when the parser "fills in" the syntactic structure in the

[4] Although Badecker and Straub (2002) found competitor effects for both pronouns and reflexives, the effect for reflexives was found in only one experiment, and resisted further attempts at replication, while the effect for pronouns was replicated in multiple experiments. This raises the possibility that competitor effects are more restricted in contexts governed by Principle A (reflexives) than those governed by Principle B (pronouns).

[5] See the Discussion section on this point in relation to the condition on reflexives in representational nominals.

ellipsis site. As noted above, this structure is required to license the binding relationship between a reflexive and an antecedent clause's subject. Consider the examples in (8a–d).

(8) a. John told some stories, but I don't know which stories about himself . . .
b. Mary told some stories, but I don't know which stories about himself . . .
c. John told some stories, but I don't know with which stories about himself . . .
d. Mary told some stories, but I don't know with which stories about himself . . .

A sluicing continuation is possible in (8a, b), but not in the minimally different (8c, d), due to the prepositional wh-phrase. The question is whether the parser builds a sluicing structure upon encountering the wh-phrase. If the parser does compute a sluicing continuation for (8a, b), then it should license a binding relationship between the reflexive and the first clause's subject, mediated by the parallel elliptical clause: the wh-phrase containing the reflexive is "reconstructed" to its thematic position, that is, the object position of the verb which is recovered into the ellipsis site. As a result, the reflexive is c-commanded by (or in the co-argument relation with) the subject NP John/Mary that is recovered into the ellipsis site, and thus the reflexive is bound by the first clause's subject due to the Binding Condition A (Chomsky, 1981).[6] This should give rise to a GMME for (8b) but not (8a), in the form of a reading-time slowdown at the position of the reflexive *himself*. In contrast, no GMME is expected for (8c) compared to (8d), since the sluicing structure licensing the binding relationship is blocked by the preposition *with*. Only a nonelliptical continuation is possible for these sentences, so no reading-time differences at *himself* would be expected.

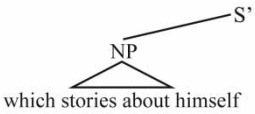
On the other hand, if the parser does not immediately calculate a sluicing continuation for (8a, b), but instead initially prefers a nonelliptical continuation (or simply remains uncommitted regarding the sentence's continuation), no GMME is expected for (8a, b) or (8c, d). No parallel clause structure will be filled in for any of the sentences, so no binding relationship between *himself* and the first clause's subject will be possible. Reading times for *himself* should, therefore, be similar across the sentences.

Investigating the processing of this type of sentence can potentially tell us how much structure the parser can build ahead of decisive bottom-up information. If the parser does project hierarchical structure of ellipsis, attempting to establish a binding relation between the reflexive inside the wh-phrase and the subject of the antecedent clause, this means that the parser must build full-fledged syntactic structure at the point of wh-phrase. However, it is important to note that at the point of the wh-phrase, there is not sufficient information that can tell the parser what structure should be built. First of all, the wh-phrase itself does not provide the parser with sufficient information regarding the upcoming structure. The only information that a wh-phrase provides is its categorial status (being an NP) and its designated position in the sentence (S'-node). Such information alone is not enough for the parser to

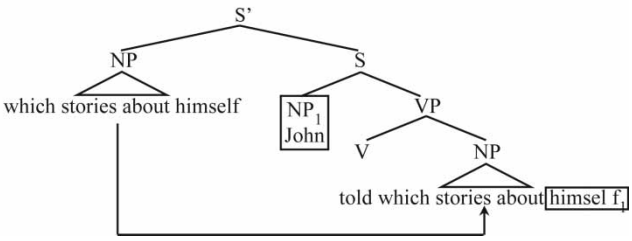
[6] An anonymous reviewer points out that if the GMME is truly contingent upon the 'reconstruction' of the wh-phrase to its thematic position, then we predict that there should be a correlation between the possibility of reconstruction and the GMME, i.e., if the reconstruction is required, GMME should be observed, but if not, GMME should not be observed. A possible testing ground for this is the asymmetry in the reconstruction depending on the type of wh-phrases: adjunct wh-phases (such as *How proud of himself was John?*) appear to undergo reconstruction obligatorily, while other classes of wh-phrases show more flexibility in this regard: see Heycock (1995), Huang (1993) for related data and discussion, and see Omaki et al. (2007) for related experimental studies on this topic.

establish a binding relation between the reflexive and its antecedent. Therefore, if the evidence suggests that the parser builds full-fledged structure at the point of the wh-phrase, it raises an interesting challenge for models of sentence processing: namely, how can the parser build a full structure for the sentence based on impoverished input information. Schematically, the parser needs to project the structure in (9b), based on the structure and information available in (9a) which involves the c-command relation between the subject NP *John* which is recovered from the first clause and the reflexive embedded inside the wh-phrase.

(9) a.



b.



To achieve the structure in (9b) from (9a), the parser has to build the exact copy of the first clause. We return to this issue in the Discussion, where we consider the type of mechanism that might achieve the structure building illustrated in (9).

EXPERIMENTS

A word-by-word self-paced moving window experiment (Just, Carpenter, & Woolley, 1982) and three offline experiments were conducted. The aims of these experiments were to examine the time course of the processing of potential sluicing structures, and to see whether sluicing is the parser's first resort.

Methods

Participants

Forty native speakers of English participated in the self-paced reading experiment. All were students at The University of Edinburgh. They were paid £5 for approximately 30 min of participation in the experiment.

Materials

Twenty four items like those in (7) were prepared (see the Appendix for the full list of stimuli). Reflexive gender (match vs. mismatch) and wh-phrase type (Wh-NP vs. Wh-PP) were independently manipulated in a two-by-two factorial design.

(10) A sample set of stimuli[7]

a. *Condition 1: Gender Match/Wh-NP*
Jane's grandfather told some stories at the family reunion[0] but[1] we[2] couldn't[3] remember[4] **which**[5] **story**[6] about[7] himself[8] from[9] the[10] party[11] his[12] brother[13] was[14] so[15] very[16] impressed[17] with.[18]

b. *Condition 2: Gender Mismatch/Wh-NP*
Justin's grandmother told some stories at the family reunion[0] but[1] we[2] couldn't[3] remember[4] **which**[5] **story**[6] about[7] himself[8] from[9] the[10] party[11] his[12] brother[13] was[14] so[15] very[16] impressed[17] with.[18]

c. *Condition 3: Gender Match/Wh-PP*
Jane's grandfather told some stories at the family reunion[0] but[1] we[2] couldn't[3] remember[4] **with**[5] **which**[6] **story**[7] about[8] himself[9] from[10] the[11] party[12] his[13] brother[14] was[15] so[16] very[17] impressed.[18]

d. *Condition 4: Gender Mismatch/Wh-PP*
Justin's grandmother told some stories at the family reunion[0] but[1] we[2] couldn't[3] remember[4] **with**[5] **which**[6] **story**[7] about[8] himself[9] from[10] the[11] party[12] his[13] brother[14] was[15] so[16] very[17] impressed.[18]

The first clauses of all the conditions before *but* were presented in one region to provide contextual information. The sentences were presented word-by-word from *but* onwards. Note that all the filler sentences are presented in a similar format, in which the first line of the sentence was presented in one region, and the second line was presented word-by-word, so that the target sentences did not stand out from the other sentences in the experiment. The presentation regions for the self-paced reading setup are indicated by the superscripts. After region 15 in conditions 1 and 2, and region 16 in conditions 3 and 4, the length of the sentences varied. Some contained extra regions and some did not, in order to keep the sentence sounding as natural as possible. A comprehension question was presented after each sentence, including fillers.

Up to the point of the wh-phrase, these sentences are ambiguous, consistent with either a sluicing or a nonelliptical continuation. In order to verify that the sentences in the (10a, b) conditions were compatible with a sluicing continuation and the (10c, d) conditions were not, a rating study and a sentence fragment completion study were conducted.

In the acceptability rating study 40 volunteers (all native English speakers at Northwestern University) rated sentences similar to (10a–d), but without the material following the reflexive anaphor *himself*. (For example, the version of (10a) judged by the volunteers was *Jane's grandfather told some stories at the family reunion but we couldn't remember which story about himself.*) The volunteers rated the sentences' acceptability on a scale of 1–5 (1 representing not acceptable and 5 fully acceptable).

The volunteers found the sentences without a preposition (10a, b) more acceptable than sentences with a preposition (10c, d), 2.75 vs. 1.99, indicating that the sluicing

[7] 5 native speakers read all the stimuli and judged the acceptability of the stimuli. They detected clear differences among four types of sentences we used in this experiment. However, as a reviewer points out, there are some items in which the combination of the head noun of the wh-phrase and the subsequent preposition (e.g., which *story of...*) sounds slightly unnatural for certain speakers. As we can see in the results, the item analyses agree with the basic contrast that we report, and thus we do not discuss this problem further.

continuation was less available for the latter sentences, $F1(1, 39) = 76.07$, $MSE = 123.984$, $p < .001$; $F2(1, 23) = 72.394$, $MSE = 123.99$, $p < .001$. Furthermore, a mismatch between the gender of the first clause's subject and the reflexive affected the acceptability of the sentences without a preposition (10a, b), but not the sentences with a preposition (10c–d). There was a significant interaction of Gender and Wh-type, $F1(1, 39) = 69.58$, $MSE = 69.876$, $p < .001$; $F2(1, 23) = 69.27$, $MSE = 69.57$, $p < .001$. Pairwise comparisons revealed that the Gender Match Wh-NP condition (10a), which received a mean acceptability rating of 3.35 was judged to be significantly more acceptable than the Mismatch Wh-NP condition (10b), which had a mean rating of 2.15, $F1(1, 39) = 125.11$, $MSE = 171.8$, $p < .001$; $F2(1, 23) = 116.21$, $MSE = 172.8$, $p < .001$; in contrast, in the Wh-PP conditions, there was no such acceptability difference between the Gender Match Condition (10c), which received a mean acceptability rating of 1.84 and Mismatch Condition (10d), which received a mean acceptability rating of 1.72 (Fs < 1). The volunteers thus found the gender-mismatch conditions less acceptable when sluicing was possible (10a, b) but not when it was blocked (10c, d). This difference suggests that a preposition attached to the wh-phrase blocks a sluicing continuation, thus blocking anaphor connectivity effects as suggested above.

A sentence fragment completion study was also conducted to further verify that the Wh-NP conditions are compatible with a Sluicing continuation but the Wh-PP conditions are not. Thirty six volunteers (all native English speakers at Northwestern University) completed sentence fragments similar to (10a–d), but without the material following the preposition *about*. (For example, the version of (10a) completed by the volunteers was *Jane's grandfather told some stories at the family reunion but we couldn't remember which story about* . . .). Note that in this experiment, reflexives are not involved, and thus the gender manipulation is not an independent factor. Results from this completion study show that volunteers were more likely to complete the fragments with Sluicing in the Wh-NP conditions than in the Wh-PP conditions. Participants provided a total of 864 completions. Completions were classified as *Sluicing Completion* if a single noun or noun phrase is provided after the preposition. Others, including blank responses, were classified as *Others*. An analysis of numbers of completion types revealed that 65.1% of Wh-NP conditions were completed with *Sluice Completions*, and 15.7% of Wh-PP conditions were completed with *Sluicing Completions*.[8] A mixed-effect logistic regression model (Baayen, 2008) revealed that there was a reliable effect of phrase type, with more sluices in the NP condition than the PP condition ($Z = 11.80$, $p < .001$).[9] This result demonstrates that the Wh-NP conditions are more compatible with sluicing structures than the Wh-PP conditions.

[8] Note that there were 15.7% of *Sluice Completions* in the Wh-PP conditions. This is not expected from the syntactic generalization discussed above. Note, however, that the five native speakers of English who we asked to informally judge the resulting sentences judged the *Sluice Completions* in the Wh-PP conditions all to be unacceptable, in contrast to those in Wh-NP conditions, which were all judged acceptable. Therefore, we suspect that these erroneous completions indicate that there was simply noise in the completion data due to the complexity of the sentences. For example, errors may have arisen from misreading of the fragments, such that the preposition was overlooked. Importantly, however, the Wh-NP conditions yielded significantly more *Sluice Completions* than the Wh-PP conditions, strongly supporting the compatibility of Wh-NP conditions with Sluicing structures.

[9] The analysis included crossed random intercepts, as well as random slope parameters for the WH factor, for participants and items.

Procedure

The experimental stimuli for the self-paced reading task were distributed across four lists using Latin Square counterbalancing. In each list, the stimuli were combined with 72 fillers in a pseudo-random order, such that no two experimental items appeared adjacent to each other. Each trial began with a series of dashes separated by spaces, indicating the positions of the words. The participant pressed the spacebar on the computer to see each subsequent region of the sentence, and the time between each button press was recorded for subsequent analysis.

Results and discussion

In the analyses of reading times, we excluded data from eight participants whose accuracy rating for comprehension questions was more than 2.5 standard deviations below the mean of all participants. We also excluded all trials for which the corresponding comprehension question was answered incorrectly. Comprehension accuracy, and reading times at each region, were analysed using a repeated-measures ANOVA, with gender of reflexive (match vs. mismatch) and the type of wh-phrase (NP vs. PP) as within-subjects and within-items factors. The average comprehension accuracy among the forty participants who were included in the analysis was 85%. Mean accuracy scores did not differ among the four conditions (Fs < 1).

Figures 1 and 2 summarise the average reading times within the Wh-NP conditions and the Wh-PP conditions separately. There were significant reading-time differences across conditions at the predicate negation region (region 3), and the reflexive region (regions 8 in Wh-NP conditions, (10a, b): region 9 in Wh-PP conditions, (10c, d)), and the preposition region (region 9 in Wh-NP conditions, (10a, b): region 10 in the Wh-PP conditions, (10c, d)). There were also significant differences at region 15. However, this region contains dramatically different material across items: some items contain clausal material such as auxiliaries, while other items contain only prepositional phrases or other sub-clausal material. Item means in this region are, therefore, difficult to compare, and any differences difficult to interpret. These differences will, therefore, not be discussed further here.

(11)

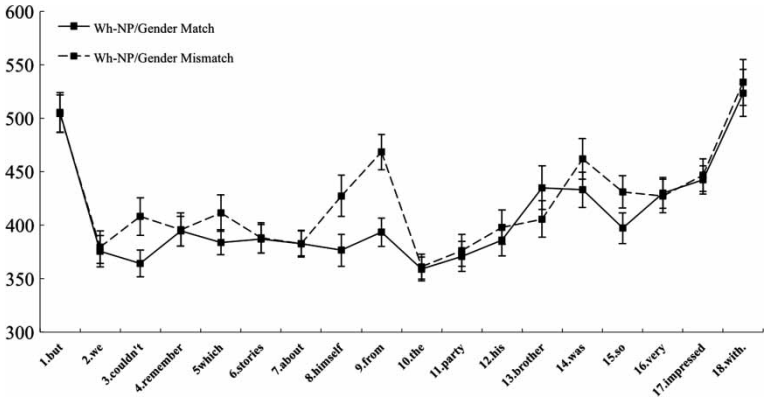


Figure 1. Mean RT for Wh-NP conditions.

(12)

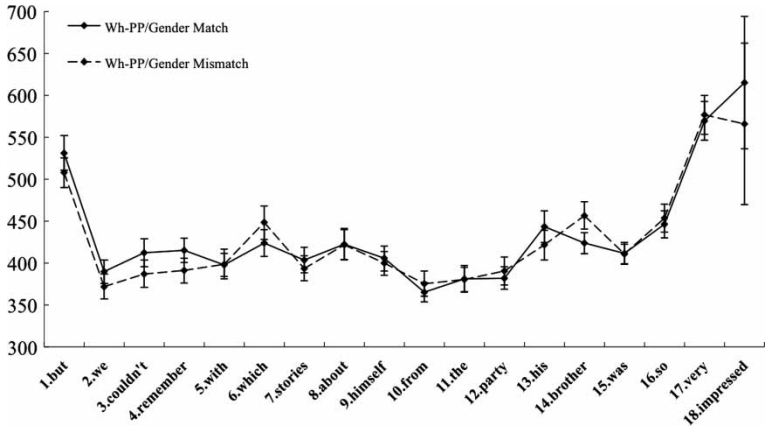


Figure 2. Mean RT for Wh-PP conditions.

Region 3 (predicate/negation) showed no main effect of Gender or Wh-type. There was an interaction of Gender and Wh-type at region 3 in the analysis by participants but not in the analysis by items, $F1(1, 31) = 7.16$, $MSE = 151{,}918$, $p < .01$; $F2 < 1$. Pairwise comparisons revealed that within the Wh-NP conditions, the Match/Wh-NP condition was read significantly more slowly than the Mismatch/Wh-NP condition, $F1(1, 31) = 10.77$, $MSE = 146{,}853$, $p < .01$; $F2(1, 23) = 5.22$, $MSE = 135{,}700$, $p < .05$, but there was no such difference between the Wh-PP conditions (Fs < 1). Note that this effect must be spurious, since Region 3 precedes and is unrelated to the WH-phrase or the reflexive. Region 8/9 (the reflexive) also showed a main effect of Gender with the Mismatch/Wh-NP condition being read significantly slower than the other conditions, though this effect was reliable by participants only, $F1(1, 31) = 5.00$, $MSE = 214{,}247$, $p < .05$; $F2 < 1$. Although the interaction in this region was nonsignificant (F's < 1), the pattern of means was as predicted by our hypothesis: pairwise comparisons revealed that within the Wh-NP conditions Mismatch/Wh-NP condition was read significantly more slowly than the Match/Wh-NP condition, $F1(1, 31) = 5.68$, $MSE = 159{,}581$, $p < .05$; $F2(1, 23) = 4.03$, $MSE = 179{,}387$, $p = .057$, but there was no such difference for the WH-PP conditions (F's < 1).

Finally, region 9/10 (the preposition following the reflexive) showed main effects of Gender, $F1(1, 31) = 10.35$, $MSE = 231{,}109$, $p < .01$; $F2(1, 23) = 6.47$, $MSE = 222{,}474$, $p < .05$, and Wh-type, $F1(1, 31) = 10.745$, $MSE = 239{,}833$, $p < .01$; $F2(1, 23) = 5.22$, $MSE = 116{,}691$, $p < .05$. Importantly, these effects were modulated by a significant interaction of Gender by Wh-type, $F1(1, 31) = 11.33$, $MSE = 253{,}017$, $p < .01$; $F2(1, 23) = 6.47$, $MSE = 222{,}474$, $p < .05$. Figure 3 summarises the interaction observed in this region.

(13)

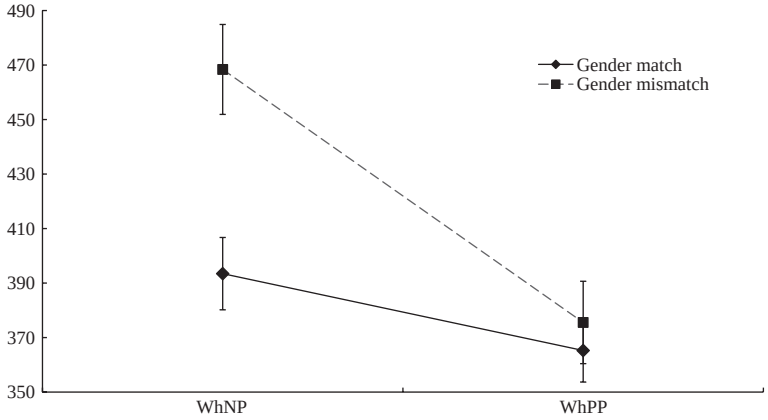


Figure 3. Interaction of gender and Wh-type at region 9/10.

Pairwise comparisons revealed that within the Wh-NP conditions the Mismatch/Wh-NP condition was read significantly more slowly than the Match/Wh-NP, $F1(1, 31) = 31.71$, $MSE = 430{,}673$, $p < .01$; $F2(1, 23) = 15.37$, $MSE = 356{,}180$, $p < .01$. On the other hand, there was no corresponding slowdown in Wh-PP conditions, $F1(1, 31) = 0.01$, $MSE = 441.225$, $p = .9$; $F2(1, 23) = 0.7$, $MSE = 16{,}465.9$, $p = .41$.

Overall, the results show that reflexives with mismatching gender in potentially sluicing conditions (10b) induced slow reading times relative to the other conditions (10a–d). The significant interaction at region 9/10 (the preposition following the reflexive) is particularly clear evidence of this effect. These findings are also consistent with the ratings and completions for truncated versions of these sentences in the norming studies reported above. Participants found a gender mismatch between the wh-phrase reflexive and the first clause's subject unacceptable if and only if a sluicing continuation was possible. This finding indicates that participants computed a sluicing structure at the position of the wh-phrase in conditions where it was grammatical, even when (as in this experiment) the sentences did not continue as sluicing sentences.

DISCUSSION

The results of this experiment strongly suggest the following conclusions. First, the sluicing structure is the parser's first choice when a sluicing continuation is possible. The anticipated gender mismatch effect was observed, but only in environments where a sluicing continuation is possible and grammatically licit. This finding is consistent with previous studies that have shown a gender mismatch effect (in measures of initial processing) only where the relation between the referential expression and its potential antecedent is grammatically licensed (Sturt, 2003 for forwards anaphora; Kazanina et al., 2007, for backwards anaphora). This is compatible with the claim that potential antecedents are only considered when there is hierarchical structure which will permit the reflexive to be grammatically related to the potential antecedent, as in the Wh-NP conditions which allow sluicing. However, in the Wh-PP conditions which do not allow sluicing, it is not clear at the point of the wh-phase whether the first clause's subject can be the antecedent of the reflexive. In such an environment, the parser does

not initiate an active search process. Of course, we do not rule out the possibility that a grammatically inaccessible antecedent might interfere with the accessible antecedent, in situations where both antecedents match in gender (Badecker & Straub, 2002; Runner et al., 2003), a condition which we do not test here. However, what is important in the current study is the online sensitivity of the parser to the licensing conditions for reflexives in sluicing environments, a finding which is compatible with our claim that the elided structure is built online.

Even though it is clear that the parser selects the sluicing structure at the point of the wh-phrase, we have to point out that there are potentially two possibilities regarding how the sluicing structure is projected. First, it is possible that encountering an embedded wh-element such as *which* or *how* can trigger the predictive structure building. Even though the wh-element is compatible with both the sluicing structure and a nonellipsis structure, the parser prefers the sluicing structure. As a result, whenever the bottom-up input is compatible with sluicing, the parser chooses the sluicing continuation. If this is the case, we may expect the same to be true for other types of ellipsis. Given that the wh-element is not a unique cue for the upcoming ellipsis, it is not likely that the parser projects ellipsis simply because the wh-element is processed. Rather, it is more plausible that the parser prefers ellipsis in general. If so, it is expected that the parser prefers ellipsis whenever the local environment is compatible with ellipsis.

There is, however, another possibility. It may also be the case that it is the reflexive that prompts the parser to choose the sluicing structure. When the parser encounters a reflexive in the wh-phrase, the reflexive initiates an active antecedent search process. If the parser constructs the sluicing structure, the structure of the first clause becomes available and this allows the parser to link the reflexive to its antecedent immediately. Thus, according to this account, the parser's structure building can be understood as a side effect of the active antecedent search process initiated by the reflexive in the wh-phrase. If this is the case, we do not expect that a parsing preference for ellipsis in general. In this scenario, the parser's preference for ellipsis is motivated by two factors: the local environment being compatible with ellipsis, and an independent requirement to establish the reflexive-antecedent relation as soon as possible. Thus, it is not clear whether the parser prefers the ellipsis structure if only one (but not the other) of these two conditions is met.

At this point, we do not have a way to distinguish these two possibilities. However, the latter possibility does make a clear prediction: evidence of predictive structure building should not be present when the wh-phrase does not contain an element like a reflexive which triggers an active antecedent search process. One comparison which might allow us to test this possibility is the comparison between sluicing and sprouting constructions, cases like *The secretary filed (something), but I don't know what, exactly* (Dickey & Bunger, 2010; Frazier & Clifton, 1998). Sprouting sentences like *The secretary filed, but I don't know what, exactly* show a reading time penalty compared to sluicing sentences (with the overt inner antecedent *something*) at the wh-phrase and immediately thereafter. If the magnitude of this penalty is affected by the structure of the antecedent clause, much as reading times for the reflexive inside the wh-phrase are affected by the presence of a potential NP antecedent in the antecedent clause in the current study, then this would provide evidence of predictive structure building independent of an active antecedent search process. We are currently conducting experiments to test this possibility (Yoshida & Dickey, 2009).

Furthermore, the results of the sentence fragment completion study offer potential evidence against this second hypothesis. As discussed above in connection with the

sentence completion study, the fragments did not contain reflexives, but sluicing completions were nonetheless observed. This finding suggests that there is a general bias towards sluicing structure when the wh-phrase is located in an environment compatible with sluicing structure, regardless of whether a reflexive is present.

Second, closely related to the first point, the parser appears to posit a fully fledged hierarchical structure inside the ellipsis site when processing sluicing. It has been observed in the literature that the processing of reflexives respects grammatical requirements (Sturt, 2003) such as Condition A of the Binding theory which states that a reflexive must be associated with an antecedent that is in a certain structural position (the so-called C-command relation) (Chomsky, 1981). If this is generally true of reflexives, then the GMME we observed suggests that the parser constructed a hierarchical structure required for the licensing of reflexives.

We now turn to consider our stimuli in terms of the literature on Binding theory. In the theoretical linguistic literature, it is sometimes argued that reflexives in the so-called representational nominals (such as those that we are using in our target sentences: *the picture of himself* or *the story about himself*) are exempt from grammatical binding constraints (Büring, 2005; Pollard & Sag, 1992; Reinhart & Reuland, 1992; Reinhart & Reuland, 1993; Runner, 2002; Runner, Sussman, & Tanenhaus, 2003, among others). Specifically, it has been argued that in a grammatical environment where reflexive and nonreflexive pronouns are in noncomplementary distribution (as in representational nominals), reflexives do not have to have a local antecedent in certain structural positions (i.e., the antecedent does not need to c-command the reflexive). Sentence (14) is an example that shows that the reflexives in these environments are acceptable even when the antecedent does not c-command the reflexive (Pollard & Sag, 1992, p. 264).

(14) John's campaign requires that pictures of himself be placed all over town.

This example suggests that the reflexives in representational nominals may not be structurally constrained. Pollard and Sag (1992) suggest that reflexives in these environments are constrained by pragmatic constraints rather than structural constraints.

If this is truly the case, our finding that the reflexive shows a gender mismatch effect in sentences like (10b) does not necessarily support the claim that a fully fledged hierarchical structure is associated with the predicted ellipsis structure. However, we would like to note some points that are in favour of our position. First, it is important to note that all of the stimuli in our experiment involve reflexives in representational nominals. Therefore, if it is the case that these reflexives are always exempt from the structural binding constraints, then we predict a processing cost for the WH-PP mismatch condition (10d) relative to (9c), contrary to our findings. If the reflexive in representational nominals does not need a local c-commanding antecedent, and if the reflexive in (10b) can access the subject NP in the first clause (*Jane's grandfather*/*Justin's grandmother*), then we can find no reason that the reflexive in (10d) cannot access the subject NP in the first clause in the same way as (10b). However, we found the gender mismatch cost only in Wh-NP condition: (10b). Even though there is a subtle difference between (10a/b) and (10c/d), namely the presence of preposition, it is not at all clear how this preposition can distinguish the reflexive's accessibility to the antecedent. As far as we can tell, the pragmatic constraints discussed in Pollard and Sag (1992) and others do not seem to predict the difference between (10a/b) and (10c/d).

Second, there is evidence that reflexives in representational nominals in sluicing environments, like those considered in this study, are in fact tightly constrained by structural conditions. First of all, these reflexives appear to require a c-commanding antecedent. The following pair of examples shows a sharp acceptability contrast, where reflexives and pronouns are in representational nominals, and the antecedent NP, *John*, is not c-commanding either the reflexive or the pronoun.

(15) a. *John's campaign requires that many pictures be placed all over town, but no one knows which picture of himself.
b. John's campaign requires that many pictures be placed all over town, but no one knows which picture of him.

As we can see clearly, unlike nonreflexive pronouns, the reflexive in (15a) is not acceptable in this environment. This contrast is also consistent with the results from a separate acceptability rating experiment we conducted to obtain further empirical evidence regarding reflexives in these contexts. We conducted an additional acceptability rating experiment similar to the one discussed earlier, using stimuli based on the stimuli used for the acceptability study described above. We manipulated two independent factors in a 2×2 factorial design: Type of pronoun in the representational nominal (Reflexive vs. Pronoun), and the gender of the subject NP (Match vs. Mismatch). A sample set of stimuli is in (16).

(16) a. Reflexive/Match
Jane's grandfather told some stories at the family reunion but we couldn't remember which story about himself.
b. Reflexive/Mismatch
Justin's grandmother told some stories at the family reunion but we couldn't remember which story about himself.
c. Pronoun/Match
Jane's grandfather told some stories at the family reunion but we couldn't remember which story about him.
d. Pronoun/Mismatch
Justin's grandmother told some stories at the family reunion but we couldn't remember which story about him.

If the reflexives in this environment are not structurally constrained, like the reflexive in (14), we do not expect any differences in acceptability among these four conditions. This is so because all the reflexives and pronouns have gender-matching antecedents either in the subject NP position or in the possessor NP position. Therefore, if the reflexives in (16a) and (16b) can access the possessive NPs as their antecedent as in (14), they should both be licensed and the sentences should be equally acceptable. On the other hand, if the reflexive in this environment is structurally constrained, then we expect that (16b) will be judged less acceptable than (16a), because there is no structurally accessible antecedent for the reflexive in (16b). (The gender matching NP does not c-command the reflexive in the structure recovered into ellipsis.) The pronoun conditions in (16c) and (16d) serve as baseline conditions. As is well known, a pronoun can freely access the NP in the possessive position as its antecedent. Therefore, we do not expect any difference in acceptability between the pronoun conditions. Moreover, if the reflexives in (16a) and (16b) can take the possessive NP as

their antecedents as easily as pronouns, then we do not expect any difference among reflexive conditions and pronoun conditions.

Twelve volunteers (all native English speakers at Northwestern University) rated the acceptability of these sentences on a scale of 1–5 (1 representing not acceptable and 5 fully acceptable). There was a main effect of Gender, $F1(1, 11) = 140.18$, $MSE = 91.04$, $p < .001$; $F2(1, 23) = 178.24$, $MSE = 91.05$, $p < .001$, and a main effect of Pronoun type, $F1(1, 11) = 114.29$, $MSE = 95.87$, $p < .001$; $F2(1, 23) = 96.93$, $MSE = 94.86$, $p < .001$. There was a significant interaction of Gender and Pronoun-type, $F1(1, 11) = 109.04$, $MSE = 68.75$, $p < .001$; $F2(1, 23) = 126.10$, $MSE = 68.77$, $p < .001$. A mismatch between the gender of the first clause's subject NP and the pronoun affected the acceptability of the sentences with a reflexive (16a, b), but not the sentences with a pronoun (16c, d). Pairwise comparisons revealed that the Gender Match reflexive condition (16a) (mean acceptability rating: 3.12) was judged to be significantly more acceptable than the Mismatch reflexive condition like (16b) (mean acceptability rating: 1.63), $F1(1, 11) = 214.55$, $MSE = 159.01$, $p < .001$; $F2(1, 23) = 271.19$, $MSE = 159.02$, $p < .001$. In contrast, the Pronoun conditions did not show such an acceptability difference between the Gender Match Condition like (16c) (a mean acceptability rating: 3.25) and Mismatch Condition like (16d) (a mean acceptability rating: 3.14) (Fs < 1).

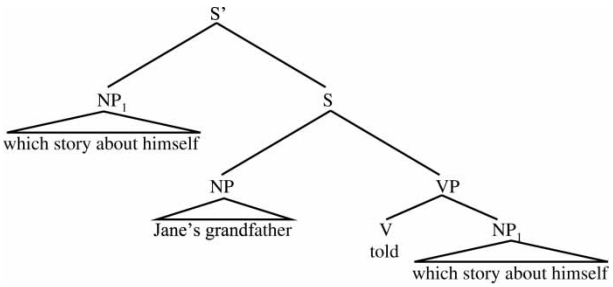
These findings suggest that reflexives inside representational nominals in sluicing environments are not easily licensed by a possessive NP in the first clause, in contrast to pronouns. This suggests that reflexives in these environments are sensitive to hierarchical structure (c-command), and are subject to the binding condition A. This finding strengthens the argument that the gender mismatch effects seen at the reflexive are due to the prediction of upcoming hierarchical structure. Therefore, we can plausibly conclude that there is a hierarchical structure associated with ellipsis that supports the binding relation between the reflexive and its antecedent.

We now consider what our evidence for predictive structure building suggests regarding parsing strategies. As discussed above, the gender mismatch effects suggest that hierarchical structure is associated with the ellipsis, and this structure supports the grammatical relationship between the reflexive and its antecedent. Such structural information cannot be read off either the wh-phrase by itself, or the reflexive. Major-category status is available for both phrases, and the wh-marking indicates the designated position that the wh-phrase occupies. However, none of this information is a decisive signal of the hierarchical structure following the wh-phrase. One might argue that the reflexive by itself can provide evidence for the upcoming hierarchical structure, because the reflexive must be bound by an antecedent that occupies a certain syntactic position. However, if this is the case, predicting such structure should be a possibility even in the Wh-PP conditions. The Wh-PP conditions should thus also be expected to exhibit the gender mismatch effect. We did not find such an effect in the experiments. The contrasting patterns for the Wh-NP and Wh-PP conditions thus strongly suggest that comprehenders actively project the ellipsis structure only in Wh-NP conditions, and that in the projected elliptical structure the reflexive is licensed if the gender of the reflexive and the antecedent matches. On the other hand, in the Wh-PP conditions, the ellipsis structure is not built. Therefore, even if the parser actively searches for the antecedent of the reflexive, the anticipated antecedent must be an upcoming overt NP rather than the NP in the elliptical structure. Given that the upcoming overt structure that contains ellipsis is not yet built at the point of the wh-phrase in Wh-PP conditions, the

reflexive is not associated with any NP. As a result, the reflexive in Wh-PP conditions does not show the GMME. The nature of this process has important consequences for theoretical and computational models of predictive structure building. Not only is the process sensitive in real time to the structural details of the syntactic context, but also the amount of structure that is predicted can be quite extensive; the current study suggests that a full clausal skeleton is predicted in cases where sluicing is a valid continuation. Both of these points imply that the predictive mechanism is more flexible and powerful than the type of top-down prediction used in parsing strategies such as the left-corner and recursive descent procedures (see Abney & Johnson, 1991; Babyonyshev & Gibson, 1995; Crocker, 1999; Gibson, 1991; Stabler, 1991; for discussion of these strategies in relation to human parsing). For example, in the left-corner strategy, the bottom-up recognition of the first constituent of a phrase triggers the prediction of subsequent constituents of the phrase. Given a context-free rule such as S → NP VP, the left-corner strategy allows for the top-down prediction of upcoming VP, once the NP node is complete. The context free rule can tell the parser that the NP is the first daughter of the S node and VP is the second daughter. Thus, given the above context free rule, processing an NP entails that the VP will follow the NP. However, the structural details of the VP are not elaborated until further bottom-up input is received. In this manner, the left corner strategy allows for a certain degree of the prediction of the upcoming structure.

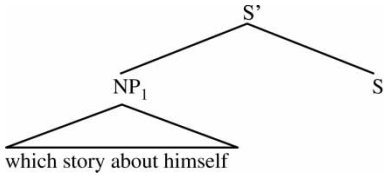
Does the left-corner strategy capture the structural prediction that we observed in the experiment? Let us discuss what is expected for sentences like (10) adopting a left-corner strategy. As we have discussed, the result of the online experiment suggests that the parser predicts a hierarchical structure which supports the binding relation between the reflexive and its antecedent upon encountering the wh-phrase. At the point of the wh-phrase, the parser projects the structure illustrated in (17).

(17)



In (17), the reflexive is not in the right structural relation (c-command relation) in its surface position. Thus, the wh-phrase that contains reflexive must be understood in its thematic position (the so-called reconstruction effect: Barss, 1986, 2001, among many others), that is, the complement position of the verb. For the sake of exposition, let us suppose that there is a context free rule for a wh-phrases such as "S' → Wh, S" as well as the rule for S that we have seen earlier. Given these rules, a left-corner parser can project the structure in (18) at the point of the wh-phrase, but nothing more.

(18)



Even if we incorporate additional information, such as that every sentence in English must have a subject, all we can get is an S node that dominates the subject NP node. The structure that is projected at the point of the wh-phrase, therefore, does support any relation between the reflexive and the subject NP in the first clause. Furthermore, the right structural relation between the reflexive and the subject NP that is recovered into the ellipsis site is not available in the partial structure in (18). Thus, in the examples considered in this paper, there would be no obvious way to link the phrase *which stories about himself* with an embedded position inside a predicted clause. One way to achieve the structure that can license the reflexive in the wh-phrase is for the parser to go through the following steps. When the upcoming S-node is recognised by means of the prediction due to the S' rule, the parser has to search for the corresponding S-node in the antecedent clause and link the empty S-node to the antecedent S-node, and copy the antecedent S-node to the empty S-node. This process allows for the recovery of the content of the elliptical site. After this linking process, the indefinite phrase (e.g., *a lot of stories*) that is copied into the ellipsis site must be replaced with the wh-phrase. Finally, the reflexive in the wh-phrase which is relocated in the thematic position is linked to the antecedent NP that is recovered into the ellipsis site. All of these steps are not available in standardly assumed left corner strategies.

One alternative explanation for our results might be that the parser predictively posits a pronoun in the subject position of the upcoming clause (*. . .which story about himself he/she . . .*), and that the gender mismatch effects are due to this predicted pronoun. If positing a pronoun in the predicted structure is possible, the difference between Wh-NP conditions and Wh-PP conditions is unlikely. There is no obvious reason why the parser would be more likely to predictively posit a pronoun in the Wh-NP conditions than in the Wh-PP conditions. If this pronoun option is available in both cases, we would not expect a difference with respect to the Gender Mismatch Effect between the two conditions. Once again, the Wh-PP conditions would also be expected to exhibit the gender mismatch effects upon encountering the reflexive. The interaction that we observed is thus unexpected if comprehenders are able to posit an upcoming gender-matched pronoun, an option which should be available in both the Wh-NP and the Wh-PP conditions. Therefore, we conclude that positing an upcoming gender-matching pronoun is unlikely to be considered by the parser in our sentences (c.f., Kazanina et al., 2007).

There may be a potential counter argument for this claim. However, one can imagine that the Wh-PP conditions are presumably very infrequent in this environment and, therefore, these conditions are too difficult to process, especially after the wh-phrase. As a result, the prediction of the upcoming subject pronoun in these conditions is not possible, due to the extreme difficulty of the conditions. This conclusion, however, seems implausible. If these conditions are too difficult to process,

this difficulty should appear either in comprehension question accuracy or in reading times. There were no significant differences in question accuracy among these four conditions (ps < 1), as discussed earlier. In addition, there was no significant difference in reading times across the four conditions from region 5/6 (wh/preposition) to region 15 (Fs < 1), other than the slowdown associated with the gender mismatch effect seen in region 9/10. More specifically, comparisons between Match/Wh-NP condition and Match/Wh-PP condition in all these regions did not reveal any significant effects (Fs < 1). Hence, there is little reading-time evidence that the Wh-PP conditions were exceptionally difficult to process. Therefore, it is reasonable to conclude that it is not the case that Wh-PP conditions are too difficult to process compared to Wh-NP conditions, and that the difficulty of Wh-PP conditions disrupted the processing of material following the wh-regions.

Here, we would like to offer a speculation on the parser's preference for the sluicing structure over other possible continuations. This preference has not been previously observed, and it is perhaps surprising: previous results have suggested that comprehenders often disprefer ellipsis interpretations of sentences, at least when other factors (such as semantic or morphosyntactic parallelism) do not favour such an interpretation (see Carlson, 2001a, 2001b, and Carlson, Dickey, & Kennedy, 2005, for discussion of potential gapping sentences). As we have discussed, sluicing, like other ellipses, requires parallelism between the sluiced clause and its antecedent. In the psycholinguistic literature it has been noted that the parser has a strong tendency to maximise the parallelism between strings in the environment of coordination (Carlson, 2001a, 2001b; Frazier, Lori, Roeper, Clifton Jr., & Ehrlich, 1984; Frazier, Munn, & Clifton Jr, 2000; Knoeferle & Crocker, 2009). Sluicing allows the parser's parallelism preference to be maximally satisfied. Furthermore, just reusing the information in the left context is sufficient for the parser to build the whole structure of the second clause. There are some data which suggest that recycling the material in the left context in order to understand ellipsis is a relatively cost-free operation (Frazier & Clifton Jr, 2000; Martin & McElree, 2008). We speculate that the parser's preference for the sluicing structure is driven by the preference for maximising the parallelism between conjoined structures, and that this preference may be reinforced by the relative ease of using information in the left context to "fill in" elliptical structure. The immediate computation of the sluicing structure would also be predicted on theories in which the processor attempts to make a maximal interpretation of the input as each word is processed in incremental parsing (e.g. Crocker, 1996).

We would like to note one potential issue regarding the current results. If the parser appeals to the sluicing structure as its first option, and the association of the reflexive to its antecedent is an index of successful structure-building, one might expect to find evidence of processing difficulty in the potential sluicing conditions when the parser encounters the disambiguating subject NP of the second clause, where it becomes clear that the ellipsis structure is no longer possible. This should lead to a slowdown specifically in the Gender match/wh-NP condition, since this is the only condition where the ellipsis alternative has not already been ruled out at this point (either through gender mismatch or structural incompatibility). However, no such effect was observed at the disambiguating second subject region (region 13 and region 14). One possible reason for not finding this effect is that the recovery required for this type of disambiguation may be relatively cost-free. If processing ellipsis involves sharing of hierarchical structure (Frazier & Clifton Jr, 2005) or a pointer to a content-addressable hierarchical structure in memory (Martin & McElree, 2008), perhaps revising these

commitments is less costly than building and revising novel hierarchical syntactic structure.

Another possible reason for the lack of the later disambiguation effect is due to the nature of the experimental manipulation. The early effect at the reflexive (and following word) involves a slow-down for the wh-NP mismatch condition relative to the wh-NP match condition. However, at the disambiguating second subject, this effect is expected to reverse in direction, with a relative slowdown for the wh-NP match condition. Thus, any delayed difficulty from the earlier mismatch cost would tend to cancel out the expected effect at the later disambiguating region. In fact, there are other areas in the sentence processing literature which give reason to suspect that this later reverse mismatch cost may lack statistical power. In an investigation of garden path sentences, Pickering and Traxler (1998) found that an initial syntactic analysis leads to immediate processing difficulty when its interpretation is implausible (relative to a plausible condition). If that analysis later becomes incompatible with disambiguating input, a reverse pattern can be observed, with greater difficulty when the initial misanalysis had been plausible (Pickering & Traxler, 1998). However, while the basic slowdown for implausible interpretations is clearly very robust, being replicated over many studies, the later *reverse* plausibility effect appears to be much less robust, and some studies have failed to replicate it (see, for example, Pickering, Traxler, and Crocker, 2000, experiment 2), and, as with the current study, one plausible reason for this is that the difference in reading times between two conditions is expected to reverse from one region of the sentence to another, making the later effect vulnerable to noise from delayed spillover effects.

Finally, we would like to point out that our findings raise a potential problem for the grammatical analyses of ellipsis. It has been reported that under ellipsis, conditions on R(eferential)-expressions such as names and variables that linked to wh-phrases do not behave in the usual way (Aoun & Nunes, 2007; Fiengo & May, 1994; Merchant, 2001, among many others). It is well known that R-expressions are subject to Condition C of Binding theory (Chomsky, 1981): an R-expression must be free. This condition explains the unacceptability of an example like (19a).

(19) a. *He thought they wouldn't arrest Alex.
b. Alex thought they wouldn't arrest him.

In (19a) an R-expression *Alex* is c-commanded by a pronoun *He*. Condition C excludes the interpretation where the pronoun and the name are co-referential.Fiengo and May (1994) observe, on the other hand, that the following example that involves VP-Ellipsis is acceptable with co-referential interpretation of the pronoun and the R-expression.

(20) They arrested Alex, though he thought they wouldn't.

Assuming (as we do) that there is a full-fledged syntactic structure associated with ellipsis, the full structure of a sentence like (20) must involve the VP that holds the parallelism with its antecedent VP, as in (21). However, this structure violates Condition C and thus a sentence like (20) is expected to be unacceptable if the structure of the sentence is as in (21).

(21) They arrested Alex, though he thought they wouldn't [$_{VP}$ arrest Alex].

One of the most influential explanations of this effect has been offered by Merchant (2001). Merchant proposes that the ellipsis does not need to hold morpho-syntactic identity with its antecedent. Rather, the ellipsis and its antecedent must hold a mutual entailment relation that is stated in terms of semantics. Merchant argues that the so-called Vehicle Change effects (Fiengo & May, 1994) illustrated in (20) and (21) are best understood as one such example, showing that absolute morpho-syntactic identity between the ellipsis and the antecedent need not hold. Under Merchant's type of analyses, there is no R-expression *Alex* represented in the ellipsis site in (20); rather, there is a bound pronoun in the position inside the ellipsis, and semantically the ellipsis site and the antecedent can hold a mutual entailment relation. The structure of (20), under this analysis, is something like (22).

(22) They arrested Alex, though he thought they wouldn't [$_{VP}$ arrest him].

In (22), the antecedent VP [arrested Alex] and the VP ellipsis involving a bound pronoun [arrest him] may hold a mutual entailment relation. In (22), what is recovered into the object position in the VP-ellipsis site is a pronoun. Therefore, this structure is subject to Condition B of the Binding theory: A pronoun cannot have a clause-mate c-commanding antecedent. In (22) the pronoun does not have a clause-mate c-commanding antecedent, and the sentence is correctly predicted to be acceptable. Let us now consider the type of sentences that we are examining in this study under this type of theory of ellipsis. If the parser can project ellipsis structure upon encountering the wh-phrase, and if the reflexive contained in the wh-phrase can be understood as pronoun, then we can obtain a structure like (23b) rather than (23a) for a sentence like (10b).

(23) a. Justin's grandmother told some stories at the family reunion, but we couldn't remember which stories about himself [~~Justin's grandmother told which stories about himself~~].
b. Justin's grandmother told some stories at the family reunion, but we couldn't remember which stories about himself [~~Justin's grandmother told which stories about ***him***~~].

Under the analysis in which any nominal expression can be replaced with a pronoun as long as the parallelism requirement on ellipsis is met, Vehicle Change effects should be possible here as well. Given that the nonreflexive pronoun does not require an antecedent in the nominative subject position, the pronoun in (23b) should be able to take the possessive NP. If so, we expect that there should be no Gender Mismatch Effect for conditions like (9b). Thus, this type of analysis of Vehicle Change effects appears to make a wrong prediction regarding the results found here.

Additionally, we would like to point out that this type of analysis also makes a wrong prediction regarding cases where the wh-phrase contains an R-expression. Unlike the cases in VP-ellipsis, Binding Condition C in sluicing environments holds quite strongly. The following pair of example shows this point clearly. In (24a) the wh-phrase contains an R-expression. In this sentence, the nonreflexive pronoun *he* cannot be co-referential with the R-expression *John* inside the wh-phrase.

(24) a. *He told some stories at the family reunion, but we couldn't remember which stories about John.

b. He told some stories at the family reunion, but we couldn't remember which stories about him.

If the R-expression can be understood as a pronoun as illustrated in (25a), then the structure of ellipsis in (24a) is basically the same as that of (24b) (= (25b)). Thus, we predict that (24a) should be acceptable, like (24b).

(25) a. He told some stories at the family reunion, but we couldn't remember which stories about John [he told [~~which stories about ***him***~~]].
b. He told some stories at the family reunion, but we couldn't remember which stories about him [~~he told [which stories about ***him***~~]].

The examples in (23) suggest that this analysis of Vehicle Change may not apply straightforwardly across ellipsis types (VP ellipsis versus sluicing) or binding conditions (Condition B versus Condition C). Thus, the findings of the acceptability judgment study suggest that a Vehicle Change analysis is needed only for a restricted range of contexts, and should not apply to all ellipsis types.

CONCLUSIONS

This study aimed to answer two questions: whether there is fully fledged hierarchical structure underlying ellipsis, and whether sluicing in the parser's first choice when confronted with structural ambiguity. Based on the results of this study, the answer to both questions appears to be "yes". The parser actively anticipates a sluicing structure when it is grammatically licensed, and prefers it to other possible continuations. Furthermore, the sluicing representations the parser generates upon encountering a wh-phrase appear to be sufficiently detailed to license a reflexive binding relationship.

Manuscript received 28 October 2009
Revised manuscript received 8 August 2011
First published online 2 March 2012

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APPENDIX
LIST OF STIMULI

1 a Nicole's father heard several stories during the holiday party but it's not clear which story of himself from the party her grandfather became so terribly upset over.
  b Nathan's mother heard several stories during the holiday party but it's not clear which story of himself from the party her grandfather became so terribly upset over.
  c Nicole's father heard several stories during the holiday party but it's not clear over which story of himself from the party her grandfather became so terribly upset.
  d Nathan's mother heard several stories during the holiday party but it's not clear over which story of himself from the party her grandfather became so terribly upset.

2 a Patty's father heard some rumours at the PTA meeting but it's not clear which rumours of himself from the meeting the janitor was very deeply concerned about.
  b Patrick's mother heard some rumours at the PTA meeting but it's not clear which rumours of himself from the meeting the janitor was very deeply concerned about.
  c Patty's father heard some rumours at the PTA meeting but it's not clear about which rumours of himself from the meeting the janitor was very deeply concerned.
  d Patrick's mother heard some rumours at the PTA meeting but it's not clear about which rumours of himself from the meeting the janitor was very deeply concerned.

3 a Nathan's mom saw lots of videos at the office party but no one was sure which video of herself from the party her secretary made such a fuss over.
  b Natalie's dad saw lots of videos at the office party but no one was sure which video of herself from the party her secretary made such a fuss over.
  c Nathan's mom saw lots of videos at the office party but no one was sure over which video of herself from the party her secretary made such a fuss.
  d Natalie's dad saw lots of videos at the office party but no one was sure over which video of herself from the party her secretary made such a fuss.

4 a Kerry's dad had some snapshots at the team party but it's not clear which snapshots of himself from the roll the quarterback was so deeply amused by.
  b Kevin's mom had some snapshots at the team party but it's not clear which snapshots of himself from the roll the quarterback was so deeply amused by.
  c Kerry's dad had some snapshots at the team party but it's not clear by which snapshots of himself from the roll the quarterback was so deeply amused.
  d Kevin's mom had some snapshots at the team party but it's not clear by which snapshots of himself from the roll the quarterback was so deeply amused.

5 a Janet's grandfather told some stories at the family reunion, but we couldn't remember which stories about himself from the party his brother was so very impressed with.
  b Justin's grandmother told some stories at the family reunion, but we couldn't remember which stories about himself from the party his brother was so very impressed with.
  c Janet's grandfather told some stories at the family reunion, but we couldn't remember with which stories about himself from the party his brother was so very impressed.
  d Justin's grandmother told some stories at the family reunion, but we couldn't remember with which stories about himself from the party his brother was so very impressed.

6 a Brittany's grandfather showed some videos at the neighbourhood barbecue but no one could remember which video of himself from the barbecue the alderman objected quite so vehemently to.
  b Brian's grandmother showed some videos at the neighbourhood barbecue but no one could remember which video of himself from the barbecue the alderman objected quite so vehemently to.
  c Brittany's grandfather showed some videos at the neighbourhood barbecue but no one could remember to which video of himself from the barbecue the alderman objected quite so vehemently.
  d Brian's grandmother showed some videos at the neighbourhood barbecue but no one could remember to which video of himself from the barbecue the alderman objected quite so vehemently.

7 a Rachel's grandpa recalled some stories during the family dinner but it's not clear which stories about himself from the dinner her brother disagreed quite so strongly with.
  b Randall's grandma recalled some stories during the family dinner but it's not clear which stories about himself from the dinner her brother disagreed quite so strongly with.
  c Rachel's grandpa recalled some stories during the family dinner but it's not clear with which stories about himself from the dinner her brother disagreed quite so strongly.

d Randall's grandma recalled some stories during the family dinner but it's not clear with which stories about himself from the dinner her brother disagreed quite so strongly.

8 a Henry's grandma exhibited some photographs at the art gallery and it finally became clear which photograph of herself from the exhibit the hostess got into so much trouble over.
b Heather's grandpa exhibited some photographs at the art gallery and it finally became clear which photograph of herself from the exhibit the hostess got into so much trouble over.
c Henry's grandma exhibited some photographs at the art gallery and it finally became clear over which photograph of herself from the exhibit the hostess got into so much trouble.
d Heather's grandpa exhibited some photographs at the art gallery and it finally became clear over which photograph of herself from the exhibit the hostess got into so much trouble.

9 a Lawrence's sister bought some drawings at the school carnival but no one could recall which drawing of herself from the carnival her girlfriend was later so surprised about.
b Lauren's brother bought some drawings at the school carnival but no one could recall which drawings of herself from the carnival her girlfriend was later so surprised about.
c Lawrence's sister bought some drawings at the school carnival but no one could recall about which drawing of herself from the carnival her girlfriend was later so surprised.
d Lauren's brother bought some drawings at the school carnival but no one could recall about which drawings of herself from the carnival her girlfriend was later so surprised.

10 a Larry's sister overheard some rumours at the school meeting but nobody actually knows which rumours about herself from the meeting her daughter got into such trouble for.
b Laura's brother overheard some rumours at the school meeting but nobody actually knows which rumours about herself from the meeting her daughter got into such trouble for.
c Larry's sister overheard some rumours at the school meeting but nobody actually knows for which rumours about herself from the meeting her daughter got into such trouble.
d Laura's brother overheard some rumours at the school meeting but nobody actually knows for which rumours about herself from the meeting her daughter got into such trouble.

11 a Justin's sister found some pictures up in the attic and it's quite obvious which pictures of herself from the attic her boyfriend was so terribly disturbed by.
b Julie's brother found some pictures up in the attic and it's quite obvious which pictures of herself from the attic her boyfriend was so terribly disturbed by.
c Justin's sister found some pictures up in the attic and it's quite obvious by which pictures of herself from the attic her boyfriend was so terribly disturbed.
d Julie's brother found some pictures up in the attic and it's quite obvious by which pictures of herself from the attic her boyfriend was so terribly disturbed.

12 a Harry's sister displayed several sketches at the art fair but no one could figure out which sketch of herself from the fair the woman got so unexpectedly upset about.
b Hannah's brother displayed several sketches at the art fair but no one could figure out which sketch of herself from the fair the woman got so unexpectedly upset about.
c Harry's sister displayed several sketches at the art fair but no one could figure out about which sketch of herself from the fair the woman got so unexpectedly upset.
d Hannah's brother displayed several sketches at the art fair but no one could figure out about which sketch of herself from the fair the woman got so unexpectedly upset.

13 a Jennifer's nephew took several pictures during art class but no classmate really knows how many pictures of himself from the shoot the teacher will get irrationally angry over.
b Josh's niece took several pictures during art class but no classmate really knows how many pictures of himself from the shoot the teacher will get irrationally angry over.
c Jennifer's nephew took several pictures during art class but no classmate really knows over how many pictures of himself from the shoot the teacher will get irrationally angry.
d Josh's niece took several pictures during art class but no classmate really knows over how many pictures of himself from the shoot the teacher will get irrationally angry.

14 a Melissa's nephew wrote some stories in writing class and no one knows how many stories about himself from the class his father was moved so deeply by.
b Michael's niece wrote some stories in writing class and no one knows how many stories about himself from the class his father was moved so deeply by.
c Melissa's nephew wrote some stories in writing class and no one knows by how many stories about himself from the class his father was moved so deeply.
d Michael's niece wrote some stories in writing class and no one knows by how many stories about himself from the class his father was moved so deeply.

15 a Cindy's nephew listened to some recordings at the studio but no one could imagine how many recordings of himself from the sessions the recording engineer would be so terribly critical of.

b Cory's niece listened to some recordings at the studio but no one could imagine how many recordings of himself from the sessions the recording engineer would be so terribly critical of.
c Cindy's nephew listened to some recordings at the studio but no one could imagine of how many recordings of himself from the sessions the recording engineer would be so terribly critical.
d Cory's niece listened to some recordings at the studio but no one could imagine of how many recordings of himself from the sessions the recording engineer would be so terribly critical.

16 a Justin's niece posted many pictures on the internet, but nobody could imagine how many pictures of herself from the website his girlfriend would get repeatedly sued over.
b Jessica's nephew posted many pictures on the internet, but nobody could imagine how many pictures of herself from the website his girlfriend would get repeatedly sued over.
c Justin's niece posted many pictures on the internet, but nobody could imagine over how many pictures of herself from the website his girlfriend would get repeatedly sued.
d Jessica's nephew posted many pictures on the internet, but nobody could imagine over how many pictures of herself from the website his girlfriend would get repeatedly sued.

17 a Michelle's uncle read descriptions of people at the party but no one really knows how many descriptions of himself from the party his nephew objected really strongly to.
b Marshall's aunt read descriptions of people at the party but no one really knows how many descriptions of himself from the party his nephew objected really strongly to.
c Michelle's uncle read descriptions of people at the party but no one really knows to how many descriptions of himself from the party his nephew objected really strongly.
d Marshall's aunt read descriptions of people at the party but no one really knows to how many descriptions of himself from the party his nephew objected really strongly.

18 a Heather's uncle heard some stories on the local news, and everyone was wondering how many stories about himself from the news his congressman eventually confessed quite belatedly to.
b Aaron's aunt heard some stories on the local news, and everyone was wondering how many stories about himself from the news his congressman eventually confessed quite belatedly to.
c Heather's uncle heard some stories on the local news, and everyone was wondering to how many stories about himself from the news his congressman eventually confessed quite belatedly.
d Aaron's aunt heard some stories on the local news, and everyone was wondering to how many stories about himself from the news his congressman eventually confessed quite belatedly.

19 a Scott's aunt found some portraits in the attic but I don't remember how many portraits of herself from the attic her niece broke into gushing tears over.
b Sarah's uncle found some portraits in the attic but I don't remember over how many portraits of herself from the attic her niece broke into gushing tears over.
c Scott's aunt found some portraits in the attic but I don't remember over how many portraits of herself from the attic her niece broke into gushing tears.
d Sarah's uncle found some portraits in the attic but I don't remember over how many portraits of herself from the attic her niece broke into gushing tears.

20 a Roberta's uncle heard some embarrassing anecdotes at the neighbours' party, but it's not clear how many anecdotes about himself from the party his son objected so very angrily to.
b Ryan's aunt heard some embarrassing anecdotes at the neighbours' party, but it's not clear how many anecdotes about himself from the party his son objected so very angrily to.
c Roberta's uncle heard some embarrassing anecdotes at the neighbours' party, but it's not clear to how many anecdotes about himself from the party his son objected so very angrily.
d Ryan's aunt heard some embarrassing anecdotes at the neighbours' party, but it's not clear to how many anecdotes about himself from the party his son objected so very angrily.

21 a Andrew's wife told some stories about her friends but it wasn't clear how many stories about herself or her friends the neighbour lady would cause a stir over.
b Amy's husband told some stories about his friends but it wasn't clear how many stories about herself or her friends the neighbour lady would cause a stir over.
c Andrew's wife told some stories about her friends but it wasn't clear over how many stories about herself or her friends the neighbour lady would cause a stir.
d Amy's husband told some stories about his friends but it wasn't clear over how many stories about herself or her friends the neighbour lady would cause a stir.

22 a Jake's girlfriend heard some rumours after class today but no one was certain how many rumours about herself from the playground her sister broke into sobs and tears over.
b Sarah's boyfriend heard some rumours after class today but no one was certain how many rumours about herself from the playground her sister broke into subs and tears over.
c Jake's girlfriend heard some rumours after class today but no one was certain over how many rumours about herself from the playground her sister broke into sobs and tears.

d Sarah's boyfriend heard some rumours after class today but no one was certain over how many rumours about herself from the playground her sister broke into subs and tears.

23 a Adam's girlfriend recalled some fond memories one afternoon and it was easy to imagine how many memories of herself from the old days her sister grew so terribly nostalgic for.

b Anna's boyfriend recalled some fond memories one afternoon and it was easy to imagine how many memories of herself from the old days his sister grew so terribly nostalgic for.

c Adam's girlfriend recalled some fond memories one afternoon and it was easy to imagine for how many memories of herself from the old days her sister grew so terribly nostalgic.

d Anna's boyfriend recalled some fond memories one afternoon and it was easy to imagine for how many memories of herself from the old days his sister grew so terribly nostalgic.

24 a Mike's girlfriend trashed several photographs in the album, though it was difficult to see how many photographs of herself from the album her older sister got such a shock from.

b Laura's boyfriend trashed several photographs in the album, though it was difficult to see how many photographs of herself from the album her older sister got such a shock from.

c Mike's girlfriend trashed several photographs in the album, though it was difficult to see from how many photographs of herself from the album her older sister got such a shock.

d Laura's boyfriend trashed several photographs in the album, though it was difficult to see from how many photographs of herself from the album her older sister got such a shock.