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PROCESSING PARASITIC GAPS

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A basic fact about sentences which contain parasitic gaps (PGs) is that their status is marginal. These sentences are generally judged to be not completely acceptable, with informants differing significantly in their degree of acceptance of them. There also appears to be systematic variation in acceptability across constructions.

The primary question addressed in this paper is whether processing difficulty contributes in any way to the marginal status of sentences containing PGs. We have performed a series of basic empirical studies on the first-pass parsing of a variety of PG constructions in English. By first-pass parsing, we mean the initial building of structure as the sentence is received word-by-word. If no structure can be built or if the wrong structure is built, then second-pass parsing, or re-analysis, is called upon to build the finally adopted structure. Surprisingly, except for a single experiment by Seely (1987), there is to our knowledge no reported psycholinguistic work which examines the processing of PGs.

Our experiments utilize the speeded on-line grammaticality judgment task (Kurtzman, Crawford, & Nychis-Florence, in press). In this task, sentences are presented to participants (native speakers of American English, ages 16-30) on a computer terminal screen one word at a time. Each word appears in turn in the center of the

screen, replacing the one that preceded it, at a rate of 300 msec per word. At some unanticipated point, either within a sentence or at the end of a sentence, presentation stops and there is a beep. This beep signals participants to respond as quickly as possible whether the sentence had remained fully grammatical up to that point. Participants respond by pressing one key marked "grammatical" or another key marked "ungrammatical". By comparing average numbers of each response and average response times across sentence types, we can determine the relative ease with which various structures are built in first-pass parsing.

We have investigated two classes of structures: adjunct clauses and subject NPs with clausal complements. When occurring in adjunct clauses, the PG follows the WH-gap; when occurring in subject NPs, the PG precedes the WH-gap. We have examined both tensed and non-tensed structures within each class.

Adjunct Clauses

Experiments 1a-b: PGs vs. Overt NPs in Non-Tensed Adjuncts. In Experiment 1a, we tested adjunct clauses which began with the temporal conjunction before or after and in which the verb was obligatorily transitive and in the gerundive form. We compared five versions, (a) through (e), as illustrated in the table. The versions differ in their final one or two words. In (a) there is a PG following the verb examining. In (b) there is also a PG following the verb, but in addition there is a manner adverb modifying the verb. In (c) and (d) there are overt nouns rather than PGs: (c) contains a pronoun, potentially coreferent with the WH-gap, and (d) contains a lexical noun. Version (e) is an ungrammatical control, ending in a preposition. (The table presents one example of a stimulus set; twelve sets were tested altogether. Each participant was presented with only one version of each set.)

For each version, the entire sentence was presented. The beep which signalled participants to respond sounded upon completion of the sentence. Question marks were presented attached to the final word.

As the table shows, participants were extremely accurate in judging (e) to be ungrammatical. Among the grammatical versions, participants judged (c) and (d) to be grammatical the most often, with no significant difference between them in number of "grammatical" responses or in response time (RT). Participants judged (a), with the PG, to be grammatical a little less often than (c) and (d). And they judged (b), with the PG plus manner adverb, to be grammatical even less frequently.

This would seem to indicate that PGs are somewhat less readily identified than are overt NPs during first-pass parsing. However, it must be noted that this task, in which participants make explicit grammaticality judgments, might well underestimate how frequently

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Experiment 1a

Which antiques did Joan buy after	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. examining? [PG]	58 ^b	818 ^b
b. examining carefully? [PG and manner adverb]	42 ^c	736 ^a
c. examining them? [pronoun]	75 ^a	683 ^a
d. examining catalogs? [lexical noun]	65 ^a	716 ^a
e. examining on? [preposition-- ungrammatical control]	7 ^d	(509)

Note: Distinct superscripts indicate statistically significant differences (at the .05 level for both subject- and item-based comparisons). Mean RTs in parentheses are computed from too few "grammatical" responses to permit statistical comparisons.

Experiment 1b

Joan examined	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. them. [no adverb]	90 ^a	660 ^a
b. them carefully. [adverb]	78 ^b	685 ^a

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PGs are identified. This is because PGs might themselves be less than fully grammatical. It is possible that in some instances the PGs in versions (a) and (b) were identified but participants nonetheless responded that the sentences are "ungrammatical" because PG constructions were not always considered to be sufficiently well-formed.

Further, we have supplementary experimental evidence which indicates that especially for version (b) the number of "grammatical" responses underestimates how frequently PGs were identified. We became concerned that the manner adverb might have caused additional parsing complexity which would independently reduce the number of "grammatical" responses. This concern stems from the fact that such adverbs can modify their verbs in varied and subtle ways, as Heny (1973), McConnell-Ginet (1982) and others have pointed out. In Experiment 1b, we compared simple declarative analogues to the adjunct clauses, with and without the manner adverb. There were significantly fewer "grammatical" responses for version (b), which contained the adverb, than for version (a) which did not. Thus, in version (b) of Experiment 1a the difficulty arising from the manner adverb likely masked how frequently PGs actually were identified.

You can also see that in Experiment 1a the response time for version (a) was significantly higher than the other response times. This can be attributed to having to process both the verb and the PG just before a response is called for. In the other versions, there was an additional word presented following the verb, and so verb processing (including initial building of the VP) could be completed well before a response was called for.

Experiment 2: PGs in Non-Tensed vs. Tensed Adjuncts. In Experiment 2, we compared non-tensed with tensed temporal adjuncts. We tested three versions. Version (a) contains a non-tensed gerundive; it is exactly the same as (a) in Experiment 1a. Versions (b) and (c) contain tensed verbs. In (b) the subject of the adjunct is a pronoun that is potentially coreferent with the subject of the main clause, while in (c) the subject of the adjunct is a distinct proper name.

In this experiment, the number of "grammatical" responses to (a), containing the gerundive, was even higher than in Experiment 1a. And, most importantly, it was significantly greater than the number of "grammatical" responses to both (b) and (c), containing the tensed verbs. There was no significant difference between (b) and (c). Thus, in first-pass parsing PGs are less readily identified in tensed than in non-tensed clauses.

Recall that the basic division in Engdahl's (1983) acceptability hierarchy of English PG domains lies between tensed and non-tensed clauses. We see then that this division is directly reflected in first-pass parsing.

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Experiment 2

Which antiques did Joan buy after	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. examining? [non-tensed]	73 ^a	803 ^a
b. she examined? [tensed; pronoun as subject]	43 ^b	834 ^a
c. Beth examined? [tensed; proper name as subject]	46 ^b	734 ^a

Experiment 3

Which antiques did Joan lift up	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. in order to examine? [PRO, PG]	68 ^a	767 ^a
b. in order to examine them? [PRO, pronoun]	67 ^a	752 ^a
c. in order for Beth to examine? [overt subject, PG]	61 ^b	757 ^a
d. in order for Beth to examine them? [overt subject, pronoun]	59 ^b	726 ^a

It is particularly interesting that we have shown a tense effect for temporal adjuncts, because Engdahl claimed that temporal adjuncts comprised an exception to the tense effect. However, she provided only one example pair to support this claim, and that example is problematic. The pair was This is the kind of food you must cook before eating and This is the kind of food you must cook before you eat. Informants judge these to be equally good. But this example has two weaknesses. First, eat can be intransitive, and so a PG may not even be posited for one or both of these sentences. Second, there are strong semantic associations among the content words food, cook, and eat. There exists psycholinguistic evidence suggesting that such strong associations can override syntactic processing difficulty (Ratcliff, 1987). In our experiment, however, we used only obligatorily transitive verbs just before the potential PG site, and we did not have any strong semantic associations among the words within a sentence. Therefore, our evidence seems to provide valid support for extending the tense effect to temporal adjuncts. And, in fact, according to most people's informal, non-speeded judgments, version (a) under Experiment 2 is better than (b) or (c).

These experiments with adjuncts indicate, then, that within non-tensed clauses, PGs are identified as readily as or only a bit less readily than overt NPs. Within tensed clauses, however, they are not readily identified.

Experiment 3: Effect of PRO vs. Overt Subject. Seely (1987) claims that PGs are more readily identified in adjuncts whose subject is occupied by PRO than in adjuncts whose subject is occupied by an overt NP. He argues that when the subject is PRO, all the material in the main clause, including the WH-phrase, remains highly available during processing of the adjunct, due to the coreference relation that PRO has with a constituent in the main clause. But when the subject is overt and non-coreferent with any constituent in the main clause, the availability of the main clause declines upon processing of the adjunct clause. Seely further argues that how readily an adjunct PG can be identified is dependent upon the availability of the WH-phrase to which the PG is related. Thus, PGs should be more readily identified if the adjunct's subject is PRO.

Experiment 3 tested Seely's claim with the non-tensed in order to adjunct construction. Versions (a) and (b) contain PRO as subject; in (a) there is a PG following the verb examine, while in (b) there is a pronoun, potentially coreferent with the WH-gap. Versions (c) and (d) contain an overt for-subject; in (c) there is a PG while in (d) there is a pronoun following the verb.

The number of "grammatical" responses was a bit higher for (a) than for (c). This would seem consistent with Seely's claim. However, an equivalent difference is observed between (b) and (d). Thus, the results indicate that there is a general difficulty

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associated with the overt for-subject--whether the sentence contains a PG or overt NP. Contrary to Seely, there is no evidence that the effect of the overt subject is specific to or greater for sentences containing PGs.<2>

Another aspect of the results is noteworthy. There was no difference in number of "grammatical" responses between versions (a) and (b) or between versions (c) and (d). Nor were there any differences in response time. Thus we have clear evidence that, for this construction at least, PGs can be just as readily identified as overt NPs. This is in contrast to the differences observed in Experiment 1a between the PG versions and the pronoun versions.

To explain this contrast, consider that the sequence in order (for Beth) to, used in Experiment 3, provides an unambiguous cue to the occurrence of an entire clause, unlike the simple temporal preposition before or after used in Experiment 1a. Consequently, in Experiment 3 the building of clause and VP structure could begin prior to reception of the verb, and so would not interfere with PG processing. But in Experiment 1a, the building of clause and VP structure could begin only upon reception of the verb, which is then immediately followed by the PG. Since the verb and PG were presented shortly before a response was called for, it is possible that there was not always sufficient time to both identify the PG and respond quickly. This would then result in the lower frequency of "grammatical" responses and in the higher response time observed in Experiment 1a for the PG versions.

Subject NPs with Clausal Complements

Experiment 4: PGs vs. Overt NPs in Non-Tensed Complements. In Experiment 4, we tested subject NPs which contained an infinitival clausal complement of the head noun. The verb in the complement was obligatorily transitive. We compared three versions, differing in the finally presented word, which immediately followed the complement verb. In version (a) there is a PG serving as object of the complement verb, followed by a main verb. In (b) there is a proper noun serving as object of the complement verb. And (c), ending in an auxiliary, is an ungrammatical control. The beep sounded after presentation of the finally presented word; and so participants were responding to incomplete sentences.

Participants were highly accurate in judging that (c) was ungrammatical. They frequently judged (a), containing the PG, to be grammatical. Thus, again it appears that PGs can be fairly readily identified. Surprisingly, however, participants tended to judge (b) to be ungrammatical, even though it is completely well-formed. We'll come to an explanation of that when we get to Experiment 7.

Experiment 5: PGs in Non-Tensed vs. Tensed Complements. In Experiment 5, we compared non-tensed with tensed clauses, which required varying the head noun. Version (a), which is non-tensed

Experiment 4

Who did your attempt to instruct	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. confuse [PG and main verb]	68 ^a	710
b. Jim [proper noun]	22 ^b	(830)
c. had [auxiliary-- ungrammatical control]	4 ^c	(997)

Experiment 5

Who did your	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. attempt to instruct confuse [non-tensed; PG and main verb]	61 ^a	898 ^a
b. statement that you instructed confuse [tensed; PG and main verb]	42 ^b	884 ^a
c. attempt to instruct Jim [non-tensed; proper noun]	48 ^b	976 ^a
d. statement that you instructed Jim [tensed; proper noun]	45 ^b	890 ^a

and contains a PG, was judged to be grammatical more frequently than (b), which is tensed and contains a PG. Thus, as with the adjuncts, we have evidence of a tense effect on the first-pass identification of PGs. And, for both (c) and (d), which are, respectively, the non-tensed and the tensed versions containing an overt proper noun, there was some tendency to judge them as ungrammatical (which we return to under Experiment 7).

Note that if the PG positions in these structures were actually occupied by WH-gaps, then they would comprise violations of subjacency. The fact that version (b)--the tensed structure containing a PG--was usually judged to be ungrammatical indicates that first-pass parsing is indeed sensitive to subjacency. That is, WH-gaps are not regularly posited at positions which would violate subjacency (or at most they are only momentarily posited at such positions). This is contrary to the spirit of claims, like those offered by Freedman & Forster (1985), that initial stages of parsing do not refer to island constraints in their building of structure.

Experiment 6: Effects of Additional Input. Experiment 6 examined further whether WH-gaps are ever incorrectly identified at PG positions. In addition, this experiment inquired whether a PG would more likely be identified if a complete sentence were presented. Version (a) is the same as the (a) versions in Experiments 4 and 5: it contains a PG followed by the main verb. Versions (b) and (c) contain an additional word, which is the final word of the sentence, as shown by the attached question mark. In (b) this final word is a temporal adverb, either yesterday or today. In (c) the final word is a pronoun, so that the only gap is at the PG position within the subject complement; hence (c) is ungrammatical.

There was no significant difference between (a) and (b) in how frequently they were judged to be grammatical. Thus, even when an additional word is presented--a word which not only provides for further processing time but which also completes the sentence--the PG is still not identified and considered to be grammatical any more frequently. We can conclude that a PG is either identified immediately, at its point of occurrence, or not at all. This supports a general view of first-pass parsing procedures such that they continuously operate on immediately presented input words, rather than "looking back" at earlier portions of the string.

Participants generally judged (c) to be ungrammatical. This indicates that even when no requisite WH-gap has been identified, the PG will not be construed as serving as that WH-gap. Thus we again see that parsing obeys subjacency.

Experiments 7a-c: Effect of No WH-Gap. Why, in Experiments 4 and 5, did participants tend to judge the versions which contained an overt NP following the complement verb to be ungrammatical? Our experiments point to a quite interesting reason. In this task, if a

Experiment 6

Who did your attempt to instruct	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. confuse [incomplete sentence: PG and main verb]	59 ^a	768 ^a
b. confuse yesterday? [complete sentence: PG, main verb, adverb]	65 ^a	798 ^a
c. confuse them? [complete, ungrammatical: PG, main verb, pronoun]	11 ^b	(892)

Experiment 7a

Who did your attempt to instruct	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. Jim [proper noun]	46 ^b	924 ^a
b. Jim confuse [proper noun, main verb]	68 ^a	913 ^a
c. Jim confuse? [complete sentence: proper noun, main verb]	71 ^a	860 ^a
d. Jim confuse yesterday? [complete sentence: proper noun, main verb, adverb]	61 ^a	786 ^a

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WH-gap can be expected, as a consequence of there being a fronted WH-phrase, then participants tend to respond "ungrammatical" if they have received a long or complex input string which still does not contain a possible position for the WH-gap. That is, participants have an active expectation for the WH-gap, and if that expectation is not satisfied after a long or complex input, then they tend to respond "ungrammatical". That is the case in Experiment 4's version (b) and in Experiment 5's versions (c) and (d). In other versions, by contrast, the main verb is presented and the WH-gap can be posited as occurring immediately following that main verb.

This explanation is supported by several experiments. In Experiment 7a, we compared version (a), which ends in an overt NP, with versions (b), (c), and (d), which contain an overt NP along with subsequent words, including a main verb and hence a possible WH-gap position. The frequencies of "grammatical" responses were significantly lower for (a) than for (b), (c), and (d).

In Experiment 7b, we observe a low frequency of "grammatical" responses for version (a), which contains a long string with no possible position for the requisite WH-gap (since it ends only with the complement verb). Version (b) also lacks a possible position for the WH-gap, but it is a shorter string, by one word, lacking the adjective. Due to (b)'s shorter length, the frequency of "grammatical" responses is higher for (b) than for (a). And in versions (c) and (d), the final word is the main verb, which provides a possible position for the WH-gap. Consequently, for both (c) and (d), the frequency of "grammatical" responses is higher than for (a).

This effect of length (or complexity) can also be seen in a different case in Experiment 7c. We have a somewhat higher number of "grammatical" responses for version (a) than for versions (b) and (c), which are one and two words longer.

In all three Experiments 7a, 7b, and 7c, we have also run similar declarative sentences as controls. Since these declaratives do not contain WH-phrases or gaps, we predicted that the frequency of "grammatical" responses would be high and that there would be no effects of length or of presence of the main verb. The results support those predictions, with the frequency of "grammatical" responses generally being well over 80%.

Thus, in Experiments 4 and 5, the low frequency of "grammatical" responses to the versions ending in an overt NP is due to those versions being long and failing to include a possible position for the expected WH-gap. Although this is an interesting fact bearing on WH-gap processing, it unfortunately means that we are not able to evaluate which kind of NP--an overt NP or a PG--is more readily identified within the non-tensed constructions of this type. But it is clear that PGs are at least fairly readily identified.

Experiment 7b

<u>Who did your</u>	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. courageous attempt to instruct {adjective, no main verb}	48 ^b	833 ^a
b. attempt to instruct {no adjective, no main verb}	68 ^a	939 ^a
c. courageous attempt to instruct confuse {adjective, main verb}	64 ^a	968 ^a
d. attempt to instruct confuse {no adjective, main verb}	66 ^a	915 ^a

Experiment 7c

<u>Who did</u>	<u>% "Gramm." Responses</u>	<u>RT (msec) for "Gramm." Responses</u>
a. George's brother {possessive}	98 ^a	929 ^a
b. George's older brother {possessive, 1 adjective}	81 ^b	980 ^a
c. George's wealthy older brother {possessive, 2 adjectives}	87 ^b	907 ^a

Conclusion

The main finding of our work is that first-pass parsing procedures can at least fairly readily identify PGs in non-tensed clauses, although not in tensed clauses. For many colleagues to whom we've described this work, the fact that any PGs can be identified in first-pass parsing is surprising. Many expected that PGs would always cause a garden-path. They seemed to assume that any marginal or marked construction cannot be easily processed. But our evidence indicates that that is not always the case, at least not for PGs.

However, a closer look at some of our results suggests that PGs in non-tensed clauses may not even be as marginal or marked as most people think. Some of the marginality may stem from other characteristics of the constructions in which the PGs appear. Note that in Experiment 1a the frequencies of "grammatical" responses to the versions (c) and (d), which contain overt NPs rather than PGs, are only 75% and 65%, even though these sentences are completely grammatical. Such frequencies are low compared to those for various other fully grammatical constructions which we have tested with this task in other studies (Kurtzman, 1989; Kurtzman, et al., in press). The low frequencies indicate that the temporal adjunct construction is inherently somewhat difficult to process, even when it does not contain a PG.

Similarly, in Experiment 7a the frequencies of "grammatical" responses to the versions (b), (c), and (d) were relatively low--ranging from 61% to 71%. Thus, the complex subject construction also appears to be inherently difficult to process.

An examination of various other constructions within which PGs may appear suggests to us that it is common for these constructions to be fairly complex and thus likely difficult to parse, whether or not they contain a PG. If this independent parsing difficulty is contributing to the relative unacceptability of PG constructions, then PGs per se in non-tensed clauses have a greater degree of grammaticality than is usually assumed.

Why aren't PGs in tensed clauses readily identified? There is no evident reason for it being more difficult for parsing procedures to identify PGs in tensed than in non-tensed clauses. Therefore, the tense effect most likely stems from there being a genuine difference in grammatical status between PGs in tensed and non-tensed clauses. (A grammatical explanation of the tense effect recently has been offered by Frampton (1990). Frampton argues against Stowell's (1985) denial of a tense effect for PG constructions; we add that Stowell's example sentences tend to be lengthy and awkward, making fine judgments on them questionable.)

It can be suggested that first-pass parsing procedures only build structures whose degree of grammaticality is above some

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criterion level. PGs in tensed clauses would fall below that criterion, at least for most speakers. For those speakers who, in informal non-speeded judgments, are more accepting of PGs in tensed clauses, even though they fail to identify them in first-pass parsing, we can say that they apply looser grammatical standards during second-pass parsing and judgment.

Finally, to return to PGs in non-tensed clauses, we can ask what is the nature of the parsing procedures which identify them. Two general possibilities can be suggested. One is that, immediately upon processing of the transitive verb, the obligatory NP is hypothesized. The representation of this NP would either be neutral between an overt NP and a PG, or it would explicitly list both these types of NP. The other general possibility is that a NP is not hypothesized in advance, but that parsing procedures are about equally able to identify an overt NP or a PG once subsequent input is received in support of one of them. The first possibility belongs to the family of parallel processing proposals (Kurtzman, 1985; Gorrell, 1987), while the second is a wait-and-see proposal (Marcus, 1980; Berwick & Weinberg, 1984). Unfortunately, our evidence so far does not enable us to say which of these possibilities is more likely. It is known that WH-gaps in some positions can be hypothesized in advance (Stowe, 1986; Kurtzman, et al., in press); it would be exciting to find that this holds for PGs as well.

FOOTNOTES

<1> However, statistical comparisons cannot be made across experiments, because entirely different sets of participants were tested in each one.

<2> Seely (1987) presents experimental evidence for his claim. Using a technique similar to the one utilized here, he observed poor performance on sentences like This is the man who the FBI seized before Jim's incriminating (as compared with ... before incriminating). Seely attributed the poor performance to the overt subject Jim's leading to a decline in the availability fo the main clause.

But there is an alternative explanation of the poor performance. It is likely that the possessive form Jim's led participants to expect a NP, since NPs occur much more frequently following possessives than do gerundive verbs. Consistent with this expectation, participants would initially identify incriminating as an adjectival form. Then, failing to find an expected noun, participants would judge the sentence to be ungrammatical. (Seely also tested ...before (Jim's) incriminating him, and found good performance. This can be attributed to him, which is overtly marked for objective case, providing positive evidence that incriminating is a gerundive verb.)

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