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TECHNICAL REPORT

Avoid Ambiguity! (If You Can)

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Avoid Ambiguity! (If You Can)

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Abstract

When people create linguistic expressions, they should avoid ambiguity. Current evidence on this is mixed. In two experiments, subjects read sentences including passive relative clauses, which can be written in full or reduced form (*The team (that was) defeated in the Super Bowl vowed revenge*); when reduced (without the *that was*), ambiguity is a threat. Subjects were told about the optional material, and instructed to include or omit it to make the sentence “easier to understand.” One experiment manipulated past participle ambiguity (*The team defeated...* is ambiguous, whereas *The team beaten...* is not). Another experiment also manipulated plausibility (*The winning team defeated...* is more ambiguous relative to *The losing team defeated...*). Past-participle ambiguity failed to influence whether subjects wrote full embedded clauses, but plausibility tended to. A third experiment verified that the ambiguous fragments are consistent with main-verb interpretations. Thus, when instructed to edit sentences to make them easy to understand, subjects avoid ambiguity not based on morphological ambiguity, but (perhaps) only as conditioned upon pragmatic, real-world knowledge. highlight certain common, but problematic, methodological practices in patient research, and alternative approaches are suggested.

It’s right there in the Gricean maxim of manner (Grice, 1975): Avoid ambiguity. The reason for this directive is obvious: An ambiguous linguistic expression is difficult to understand, and so to produce one is to be uncooperative (unless of course the aim is to *flout* the maxim of manner, but that’s a different matter entirely). Therefore, speakers -- or, more relevantly in the present context, writers -- should avoid ambiguity when they can.

The “avoid ambiguity” component of the Gricean maxim of manner is obviously important when *full ambiguity* is at stake. Full ambiguity arises when a complete linguistic expression can be interpreted in more than one way. The recommendation, “I can’t say enough good things about this candidate,” is fully ambiguous. (Is the candidate stronger than words can express? Or is the candidate not worthy of positive description?) However, *temporary ambiguity* too is likely to be problematic for linguistic communication. Temporary ambiguity arises when part-way through, a linguistic expression can be interpreted in more than one way, but by the end of the expression, the inappropriate interpretation becomes impossible. Temporary ambiguities are called *garden paths* when, at the point of ambiguity, linguistic or contextual factors encourage the ultimately incorrect interpretation. “The team defeated in the Super Bowl vowed revenge next season” is a garden path, because after reading “The team defeated...,” the main-verb interpretation (whereby *defeat* is a main verb and so the team did

the defeating) is especially likely; however, by the end of the expression, this main verb interpretation proves incorrect, because *defeat* is actually a passive verb in a relative clause (implying that the team got defeated). Garden paths pose demonstrable problems for readers (as shown by the last few decades of research on language comprehension), and so, by the logic described above, writers should avoid them too. (In fact, once the wider contexts of utterances in natural language use are taken into account, this distinction between full and temporary ambiguity is likely to collapse. “I can’t say enough good things” is likely unambiguous in its larger context, though its tolerance of an inappropriate [here opposite] interpretation might pose temporary comprehension difficulties.)

So, do speakers avoid full ambiguities or garden paths? Many investigations have explored this question. Two early (and conflicting) observations relevant to this point come from Elsness (1984). He looked at naturally occurring text from the Brown corpus (a variety of written forms, including books, periodicals, government documents, etc.), investigating “that” omission in fully ambiguous sentences like “The newspaper reported (that) yesterday (that) the politician had lied” (without one of the “thats,” it is uncertain whether the reporting or the lying happened yesterday). He found that sentences with such medial adverbials (“yesterday”) indeed included “thats” more often than other similar sentences, suggesting a disambiguating function for

the “that.” (Note, however, that it may be the presence of the adverbial *per se*, rather than its ambiguity, that may compel “that” inclusion.) In the same report, Elsness also assessed sentences like “The newspaper reported (that) you had lied.” Such sentences can include a temporary ambiguity, because upon its comprehension, “you” might either be the direct object of the preceding main verb, or the subject of an upcoming embedded-clause verb. Including the optional “that” eliminates this ambiguity. However, the ambiguity only arises for case-ambiguous pronouns (or noun phrases in general) like “you” or “it”; for a case-unambiguous pronouns like “she” or “he,” the sentence is never ambiguous (“The newspaper reported she...” can only be interpreted with “she” as the subject of an upcoming embedded verb). Elsness found no tendency to use “thats” more often in sentences with ambiguous pronouns, in which the “that” can disambiguate, than in sentences with unambiguous pronouns, in which the “that” need not disambiguate. This suggests that the optional “that” does not serve a disambiguating function.

Another observation from a corpus analysis comes from Temperley (2003). He also examined the Brown corpus, and suggested that optional “thats” were used to avoid temporary ambiguities (which were likely garden paths as well) that arise with relative clause structures like “the lawyer companies like...” (because “lawyer companies” could be a compound noun).

A number of laboratory studies have also investigated ambiguity avoidance. Ferreira and Dell (2000) explored a contrast similar to Elsness’s (ambiguous versus unambiguous pronouns), by having subjects say sentences from memory. Like Elsness, we found no tendency for speakers to use “thats” to avoid garden paths. Similarly, Arnold, Wasow, Asudeh, and Alrenga (2004) had subjects say sentences like “The judge sent the letter to the president to the members of the congressional subcommittee,” which include a temporary ambiguity (momentarily, “to the president” sounds like where the letter is sent -- as if it attaches ‘high’ to the verb phrase -- rather than what kind of letter was sent -- attaching ‘low’ to the noun phrase). The ambiguity can be avoided by phrasing the sentence as, “The judge sent the members of the congressional subcommittee the letter to the president.” When speakers rephrased paraphrases of sentences like these with the instruction to create maximally understandable new sentences, no tendency for them to use the unambiguous rather than the ambiguous

forms of these sentences was observed. On the other hand, Haywood, Pickering, and Branigan (2005) found that when speakers took turns instructing each other to carry out actions with utterances like “put the penguin (that’s) in the cup (that’s) on the plate,” they used “that’s” more in ambiguous circumstances (when either instruction was possible) than in unambiguous circumstances (when only one instruction was possible). (However, see Kraljic & Brennan, 2005 described below.)

Ferreira, Slevc, and Rogers (2005) looked at ambiguity avoidance by investigating speakers’ object descriptions in a communication task. The objects were made ambiguous either by including in the same displays other different objects that happened to have the same name (e.g., a flying-mammal bat was to be described in displays also including a baseball bat), or by including objects of the same type that differed in some describable way (e.g., a flying-mammal bat accompanied by a larger flying-mammal bat). Results showed that this latter *nonlinguistic* form of ambiguity was easily avoided (the ambiguity is nonlinguistic because it arises from the conceptual similarity between objects of the same type, not directly because they happen to be described with the same words). However, the former *linguistic* ambiguity was avoided very weakly, and only under specific circumstances (the ambiguity is linguistic because the only reason for the ambiguity is that the otherwise distinct objects happen to have the same name). These results suggest that speakers strive to avoid ambiguity in general, as shown by their avoidance of nonlinguistic ambiguity, but they nonetheless have greater difficulty avoiding linguistic ambiguity, and they seem to do so only under specific circumstances. (Note that the ambiguities under scrutiny throughout this paper are linguistic in nature.)

A number of reports have looked at whether speakers alter the prosody of sentences to avoid ambiguity, and most have found this not to be the case. Kraljic and Brennan (2005) had speakers describe displays to listeners, and found that they did not use different prosody for sentences like “put the dog in the basket on the star” when describing ambiguous displays (when either instruction was possible) versus unambiguous displays (when only one instruction was possible). (And, unlike Haywood et al. described above, they did *not* find that speakers used additional lexical material more often in ambiguous rather than unambiguous situations.) Schafer, Speer, Warren, and White (2000) also found that speakers failed to use disambiguating prosody specifically in

ambiguous situations in a scripted game-playing tasks. Allbritton, McKoon, and Ratcliff (1996) had subjects read aloud ambiguous sentences of a number of different types, and found that they used disambiguating prosody only when explicitly told about the possible ambiguity of the sentences. Similarly, Snedeker and Trueswell (2003) found that when speakers gave instructions to act on displays to one another (e.g., “tap the frog with the flower”), they used disambiguating prosody, but only if they were explicitly aware of the ambiguity.

In short, whereas most evidence suggests that speakers do not systematically avoid ambiguity (Allbritton et al., 1996; Arnold et al., 2004; Elness, 1984; Ferreira & Dell, 2000; Ferreira et al., 2005; Kraljic & Brennan, 2005; Schafer et al., 2000), some evidence suggests that speakers sometimes avoid ambiguity, at least under certain circumstances (Allbritton et al., 1996; Elness, 1984; Ferreira et al., 2005; Haywood et al., 2005; Snedeker & Trueswell, 2003; Temperley, 2003). Specific reasons for this mixed picture are not yet known, but it is likely that the heterogeneity of the tasks, the ambiguities, and the assessed linguistic properties are relevant. The different investigations above explored different production modalities (edited written text vs. spoken utterances), different naturalistic conditions (production from memory vs. different kinds of monologue and dialogue tasks), different forms of ambiguity (garden paths, full ambiguities, prepositional-phrase attachment ambiguities, main-verb vs. relative clause ambiguities, subject vs. object ambiguities, noun-noun compound vs. noun-relative clause ambiguities, etc.), different ambiguity-avoidance devices (mention of optional words, use of alternative word orders, prosody), and whether speakers are aware of ambiguities or not, just to name a few factors. Each of these differences might correspond to specific conditions under which speakers avoid ambiguity, or might introduce confounding factors that could lead to the appearance of avoidance or non-avoidance.

The objective of the present experiments was to determine the limiting conditions on ambiguity avoidance. Specifically, if we simply ask subjects to avoid ambiguity (in lay terms, by asking them to write sentences that are “easier to understand”), what kinds of ambiguity do they avoid and what kinds do they not avoid? Thus, the question is not whether speakers naturally avoid ambiguity when speaking or writing, but rather, whether speakers can avoid ambiguity at all.

To do this, subjects were shown sentences, instructed as to how they could change those sentences (which will be the ambiguity-avoidance device that will be assessed), and asked to make that change (or not) so as to make the resulting sentence “easier to understand.” The sentences were manipulated for whether they would be ambiguous even without the disambiguating device. If speakers avoid garden paths, they should use disambiguating devices more in sentences that need those disambiguating devices - in ones that would otherwise be ambiguous -- than they do in sentences that do not need those disambiguating devices.

For example, take the sentence “The team defeated in the Super Bowl vowed revenge the next season.” As noted, after “defeated,” the sentence contains a garden path, because “defeated” is easily interpreted as a main verb when really it is a passive verb in a relative clause. One reason for the garden path is that the passive relative clause in the sentence (“defeated in the Super Bowl”) is *reduced* -- the sentence does not include an optional relative pronoun (“who” or “that”) and auxiliary verb (“was,” “were,” etc.). If it did -- “The team *that was* defeated in the Super Bowl vowed revenge the next season” -- the garden path is eliminated. So, in the experiments, subjects were alerted to the option of using this optional material:

Please read each of the following sentences. Each of them can contain two optional words, like *that was*, *who were*, *that is*, and so forth. In some of them, we have inserted those optional words into the sentence, but the sentence would be easier to understand if they weren't there. For other sentences, we have left the optional words out, but the sentence would be easier to understand with those optional words back in.

(Note that subjects were instructed that sentences would be easier to understand without the optional words so they wouldn't adopt a strategy of always including them.) Then, subjects were instructed:

Look at each sentence, and rewrite it with or without the *that was* (or *that were*, or whatever), depending on which would be easier to understand. If the sentence would be easier to understand with the *that was*, make sure that it's there, but if it would be easier to understand without the *that was*, make sure that it's not.

In short, these instructions practically beg subjects to avoid ambiguity by inserting (or omitting) specific optional material in written sentences.

Below, two experiments are reported that were conducted with this “copy editor” task (between which a comprehension norming study is reported). In the first experiment, subjects were shown two kinds of sentences (half of each containing the optional material). In one, the form of the critical past-participle verb was ambiguous, such as the above “defeated.” In the other, the form of the critical past-participle verb was unambiguous. For example, take the (reduced) sentence, “The team *beaten* in the Super Bowl vowed revenge the next season.” The verb “beaten” has an unambiguous “-en” past-participle suffix rather than an ambiguous “-ed” past-participle suffix. Therefore, the sentence is unambiguous even when it is reduced: “the team beaten” cannot be taken such that “beaten” is a main verb (i.e., the team could not have beaten anything; they must have been beaten). (For evidence that readers find reduced relative-clause sentences with unambiguous past participles easier to understand, see Trueswell, Tanenhaus, & Kello, 1993.) If speakers are at least in principle sensitive to this ambiguity-relevant property (i.e., past-participle ambiguity), subjects in this copy-editor task should be more likely to write full relative clauses into sentences that have ambiguous past-participle verbs (“The team that was defeated...”) than into sentences that have unambiguous past-participle verbs (“The team that was beaten...”).

Experiment 1

Method

Subjects. Forty members of the University of California, San Diego community participated for class credit or monetary compensation. All reported English as their native language.

Materials, design, procedure, and analysis. Four versions of 24 sentences were created, each with a main subject modified by a passive relative clause. Two versions of each sentence included full relative clauses whereas the other two versions included reduced relative clauses (the *reduction* factor). Crossed with this, two versions of each sentence included an ambiguous past-participle verb whereas the other two versions included an unambiguous past-participle verb (the *ambiguity* factor). Figure 1 below includes examples of each sentence type.

Four booklets each included one version of each of the 24 sentences, six from each experimental condition. Sentences were rotated through each experimental condition across booklets. Each booklet was given to ten subjects. Therefore, both reduction and ambiguity were manipulated within subjects and within items in a counterbalanced design.

Booklets were given to subjects along with a detailed instruction sheet that (a) described the nature of the optional material, (b) provided examples of sentences with optional material, and (c) asked subjects to omit or include the optional material so as to make the sentences “easier to understand” (see above for text). Subjects were required to rewrite sentences even if they didn’t change them. Each written response was coded for whether it included or omitted the optional material. Responses were excluded if subjects did not rewrite the sentence or made changes to the sentences other than turning a full into a reduced form or vice versa.

Full-relative clause proportions were calculated per condition for each subject (across sentences) and for each sentence (across subjects) by dividing the number of sentences written with full relative clauses by the total number of sentences written either with full or with reduced relatives. Proportions were entered into separate two-way repeated-measures analyses of variance (ANOVAs) with subjects (*F1*) and sentences (*F2*) as random factors. Effects reported as significant reached a *p*-value of .05 or less, unless indicated otherwise. Proportions are reported as percentages for readability. Variability is reported with 95% confidence-interval halfwidths of mean differences, computed based on AVOVA output (Loftus & Masson, 1994; Masson & Loftus, 2003).

Results and discussion

Subjects failed to rewrite an analyzable sentence on 22 out of 960 responses (5 times in three of the conditions, 7 times in the fourth condition); these responses were excluded. From the remaining 938 trials, the mean percentages of sentences that subjects wrote with full relative clauses in each experimental condition are shown in Figure 1. Numerically, subjects wrote 3.7% more full relative clauses in sentences including ambiguous past-participle verbs (bottom two bars; 59.0%), than in sentences including unambiguous past-participle verbs (top two bars; 55.3%). However, this effect of ambiguity was not significant, $F1(1, 39) = 1.61, p > .20, CI = \pm 6.0\%$, $F2(1, 23) = 1.16, p > .25, CI = \pm 6.7\%$. Thus,

though subjects appear to include full relative clauses so as to avoid potentially disruptive garden path sentences, there is no statistical evidence supporting such an effect. (To determine whether this difference might approach significance with more power, 30

additional subjects were tested. The ambiguity difference dropped slightly to 3.1% and remained nonsignificant, $F(1, 69) = 1.92, p > .17, CI = \pm 6.3\%$, $F(1, 23) = 1.69, p > .20, CI = \pm 6.2\%$).

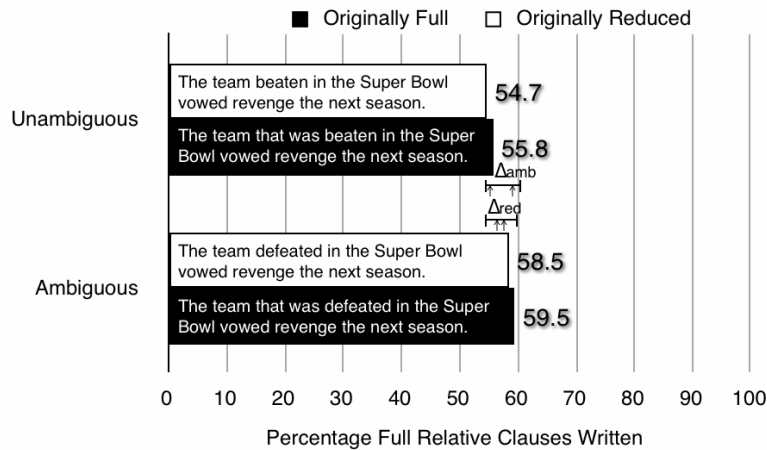


Figure 1. Percentages of full relative clauses written for sentences with unambiguous and ambiguous past-participle verbs, when originally presented with sentences with full and reduced clauses. Error bars illustrate 95% confidence interval of the main effects differences, with arrows on error bars indicating main effects means.

Subjects were no more likely to write a full relative clause into sentences that were originally presented with a full relative clause (black bars; 57.7%) compared to in sentences that were originally presented with a reduced relative clause (white bars; 56.6%), $F(1, 39) < 1, CI = \pm 11.1\%$, $F(1, 23) < 1, CI \pm 6.5\%$. This suggests that subjects did not tend to preserve the form of the sentence they were originally presented with. The ambiguity difference did not vary depending on the form of sentences subjects were presented with (a 3.7% difference when sentences were originally presented with full clauses, vs. a 3.8% difference when sentences were originally presented with reduced clauses), $F(1, 39) < 1, CI = \pm 8.7\%$, $F(1, 23) < 1, CI = \pm 9.2\%$. Such an interaction might have been expected, if subjects were more sensitive to ambiguity only when they themselves experienced the ambiguity (i.e., when encountering the sentence originally in reduced form). Of course, the absence of any such interaction suggests that subjects are not sensitive in this way.

In sum, in a task where subjects were all but explicitly asked to use full relative clauses to avoid ambiguity, they did not robustly do so as a function of the ambiguity of the past-participle verb. There was, however, a numerical difference in the predicted direction. This suggests perhaps that the ambiguity assessed in Experiment 1 was too weak -- that “the team defeated” may not be sufficiently likely to continue with “defeated” as a main verb so as to be assessed as difficult by speakers. Experiment 2 assesses this possibility. .

Experiment 2

To determine whether the ambiguous sentences tested in Experiment 1 had any potential to cause ambiguity, a written completion study was conducted (this study was briefly described in Ferreira & Dell, 2000). Subjects were given the initial fragments of the sentences used in Experiment 1 either with an ambiguous verb or an unambiguous verb (e.g., “The team defeated...” or “The team beaten...”). They were instructed to complete these fragments with “the first

completion that comes to mind.” If the sentences assessed in Experiment 1 were ambiguous at all, writers should tend to complete fragments containing ambiguous verbs (“The team defeated...”) with main-verb continuations, and more so than they do with fragments containing unambiguous verbs (“The team beaten...”). (Of course, it is difficult to complete “The team beaten...” with a grammatical main-verb continuation at all. As such, the unambiguous condition should be seen more as a kind of zero baseline. Thus, any tendency for writers to provide main-verb continuations for ambiguous fragments more than for unambiguous fragments should be seen as a greater-than-zero likelihood for ambiguous fragments to be interpreted with main verb continuations. Furthermore, to put the ambiguous and unambiguous conditions on somewhat more equal footing, ungrammatical main-verb completions will be included [e.g., “The mailman mistaken the house...”], under the assumption that such ungrammatical forms would have been understood as likely main verb continuations in the production studies as well.)

Method

Subjects. Forty members of the University of Illinois at Urbana-Champaign community participated for course credit or cash payment. All reported learning English as a native language.

Materials, design, procedure, and analysis. The main subject and past-participle verbs from the 24 sentence pairs tested in Experiment 1 were used to create 24 pairs of sentence-onset fragments of the form “The team defeated...” and “The team beaten...” Thus, the only factor in this experiment is *ambiguity*, reflecting whether the verb included in the sentence-onset fragment is ambiguous between past-tense and past-participle interpretations (“defeated”) or not (“beaten”).

Two lists each included one version of each of the 24 sentences, twelve from each experimental condition. Sentences were rotated through each experimental condition across booklets. Each booklet was given to twenty subjects. Therefore, ambiguity was manipulated within subjects and within items in a counterbalanced design.

At the top of each list were detailed instructions that asked subjects to read each sentence beginning and complete it with the first completion that came to mind. Two example fragments were included, one with an unambiguous verb (“The delicate vase broken...”) and one with an ambiguous verb (“The hockey player shot...”), neither of which was used in

the tested fragments. Subjects were instructed to take as much time as they needed.

Each written response was coded for whether it continued such that the initial verb was interpreted as a main verb, a passive relative clause verb, or in some other way. Such “other” responses were excluded from analysis.

The proportion of main-verb continuations were calculated per condition for each subject (across sentences) and for each sentence (across subjects) by dividing the number of sentences written with main-verb continuations by the total number of sentences written either with main or relative-clause continuations. Proportions were entered into separate paired *t*-tests with subjects (*t*₁) and sentences (*t*₂) as random factors. Other details of analysis are like in Experiment 1.

Results and discussion

Subjects completed sentences using structures other than main verb or relative clause continuations on 6 out of 960 responses (every time in the unambiguous condition); these responses were excluded. For the remaining 954 trials, subjects completed fragments including ambiguous verbs with main-verb continuations 62.9% of the time, whereas they completed fragments including unambiguous verbs with main-verb continuations 3.2% of the time. This difference of 59.7% was significant, *t*₁(39) = 19.6, CI = ±6.2%, *t*₂(23) = 10.2, CI = ±12.1%. Thus, subjects adopted main-verb interpretations (instead of relative-clause interpretations) substantially more often for fragments with ambiguous verbs than for fragments with unambiguous verbs (which were almost never interpreted as main-verb fragments).

These results provide a minimum standard for considering the main-subject-plus-relative-clause-verb fragments with ambiguous verbs to in fact be ambiguous. The results can be roughly interpreted as, given a fragment like “The team defeated” and no other information, a reader could be estimated to expect a main-verb continuation about 63% of the time. This makes it reasonable to claim that writers in a copy-editor task with these materials should assume that reduced-relative sentences containing ambiguous verbs are ambiguous to some non-zero degree, and furthermore that the reduced-relative sentences containing ambiguous verbs should be considered more ambiguous than reduced-relative sentences containing unambiguous verbs.

All that said, the results of Experiment 2 should be interpreted with some caution. First, writers’ sentence completions in Experiment 2 were based only on the

main subject and (sometimes ambiguous) relative clause verb; any subsequent material was unable to influence writers' sentence completions. If writers in the copy-editor task of Experiment 1 (tacitly) assume that readers have some 'look ahead' -- that readers' degree of disruption is sensitive to some amount of material beyond the relative-clause verb -- then Experiment 2's measure will overestimate the ambiguity that readers would experience. It is worth noting, however, that at least under some circumstances, language comprehenders have been revealed to be radically incremental (and even anticipatory) in their interpretation (Altmann & Kamide, 1999); this suggests that it is reasonable to assess the ambiguity of just the subject-plus-verb fragments, as some interpretation on the basis of those fragments is likely. Also, note that in Experiment 1, only 25% of the sentences that writers read were temporarily ambiguous (because half had unambiguous verbs, and half of the sentences with ambiguous verbs included full relative clauses). In contrast, 50% of the sentences writers completed in Experiment 2 were temporarily ambiguous (because they never saw unreduced fragments). This difference may make Experiment 1 participants less sensitive to ambiguity (because they assume it is less prevalent overall in the task) than Experiment 2 participants.

Experiment 3

Experiment 3 had two aims. The first was to replicate or disconfirm the (null) effect of ambiguity avoidance as conditioned on past-participle ambiguity that was observed in Experiment 1. The second was to investigate a different ambiguity-relevant factor that writers might be sensitive to. One possible explanation for the (statistical, at least) insensitivity revealed in Experiment 1 is that morphological distinctions -- the ambiguity of the past-participle marker -- may be unavailable to production mechanisms as they formulate sentence forms. Instead, an "earlier" factor that can exacerbate ambiguity, namely *plausibility*, might be relevant. With passive relative clauses, the relevant plausibility is the likelihood in terms of real-world knowledge that the subject noun phrase and (ultimately past-participle) verb describe a subject-main-verb interpretation rather than a subject-passive-relative interpretation. Here, plausibility is operationalized as *thematic fit* (McRae, Spivey-Knowlton, & Tanenhaus, 1998): A subject-main-verb interpretation implies an agent-verb relationship ("The team defeated..." with "defeated" as a main verb, implies that "team" is an agent or performer of

an action), whereas subject-passive-relative interpretation implies a patient-verb relationship ("The team that was defeated..." implies that "team" is a patient or something an action was performed on). Reading time evidence and computational modeling has shown that readers can be pushed toward interpretations of ambiguous structures as encouraged by plausibility or thematic fit (Garnsey, Pearlmutter, Myers, & Lotocky, 1997; McRae et al., 1998). Because plausibility is based on subjects' real-world knowledge, and real-world knowledge is presumably consulted before or as an utterance is formulated, it may be more likely to influence the use of an ambiguity-avoidance device. This could contrast with past-participle ambiguity, which as a morphological property of utterances, may not be consulted until too late into the formulation process, thereby proving unable to influence the use of an ambiguity-avoidance device.

Accordingly, Experiment 3 manipulated the to-be-rewritten sentences two ways: First, as in Experiment 1, the past-participle verb could either have an ambiguous (e.g., "defeated") or an unambiguous (e.g., "beaten") suffix. Crossed with this, the subject noun was either a plausible agent ("The winning team defeated...") or a plausible patient ("The losing team defeated...") of the past participle verb. The plausible-agent interpretation, by encouraging the ultimately incorrect main-verb interpretation, exacerbates the garden path. If subjects are sensitive to ambiguity as conditioned upon real-world knowledge, they should write sentences with full-relative clauses more often with agent-plausible than with patient-plausible subject nouns. If subjects are sensitive to ambiguity as conditioned upon verb ambiguity, they should rewrite sentences with full relative clauses more when they include ambiguous past-participle verbs. If subjects are sensitive to the joint effects of these factors, they should write full relatives more often with agent-plausible than with patient-plausible subject nouns, but only when the sentence includes an ambiguous past-participle verb (because unambiguous verbs are unambiguous regardless of the plausibility of the subject noun phrase).

Method

Subjects. Forty-eight subjects from the same population as Experiment 1 participated in Experiment 3.

Materials, design, procedure, and analysis. Eight versions of the 24 sentences assessed in Experiment 1 were designed for Experiment 3. The ambiguity of the past-participle verb and whether the sentence

included a full or reduced relative clause was manipulated as in Experiment 1. Crossed with these, the *plausibility* of the main subject as an agent or patient of the relative clause verb was also manipulated. Examples of a sentence manipulated for ambiguity and plausibility are shown in Figure 2 (whether the sentence originally included a full or reduced relative clause is not shown).

Plausibilities of agent-plausible and patient-plausible subject noun phrases were established with a norming procedure conducted on a separate group of 48 subjects (who were taken from the same population as the other subjects; one subject was dropped for doing only half the procedure). For each main subject and verb, subjects were asked for agent ratings with questions like (for example), “How reasonable is it for a winning team to defeat something or someone?”, and they were asked for patient ratings with questions like (for example) “How reasonable is it for a winning team to be defeated by something or someone?” (with underlined material replaced to accommodate the specific main subject or verb). Ratings were on a 1 to 7 scale, with 1 anchored as “very reasonable” and 7 anchored as “very unreasonable.” To assess the plausibility of sentences, an “agent advantage” score was calculated by subtracting the agent rating for a subject-plus-verb combination from the patient rating for that subject-plus-verb combination. Positive numbers on the agent-advantage scale indicate that the subject-plus-verb makes for a good agent combination, whereas negative numbers indicate that the subject-plus-verb make for a good patient combination. Plausible agents overall had a mean agent advantage of 1.44, whereas plausible patients overall had a mean agent advantage of -1.80. This difference was significant, $F(1,46) = 129$, $CI = \pm 0.57$, $F(1,23) = 54.1$, $CI = \pm 0.90$.

Eight booklets of sentences were created. Each included one version of each of the 24 sentences. So as not to reduce the number of items per condition, the reduction manipulation was partially confounded with the ambiguity and plausibility manipulations. Specifically, for half of the booklets, the agent-plausible/ambiguous sentences and the patient-plausible/unambiguous sentences were presented with reduced relative clauses and the other two types of sentences were presented with full relative clauses; for the other half of booklets, these assignments were reversed. This design allows six items to appear in each of the critical ambiguity and plausibility conditions (though, as noted below, it precludes doing a three-way ANOVA by subjects). Each booklet was given to six subjects.

The procedure and coding were as in Experiment 1.

Separate ANOVA designs were used by subjects and by sentences. With subjects as the random factor ($F1$), critical analyses were undertaken with two-way ANOVAs using ambiguity and plausibility as within-subject factors. Subsidiary analyses were conducted using ambiguity and reduction, and plausibility and reduction as factors. Only significant main effects of and interactions with reduction are reported from subsidiary analyses. With sentences as the random factor ($F2$), a full three-way within-sentences ANOVA was conducted with ambiguity, plausibility, and reduction as factors. In all cases, the dependent measure was the same as in Experiment 1 (proportion of sentences in a condition across sentences [by subjects] and across subjects [by sentences] produced with full relative clauses).

Results and discussion

Subjects failed to provide an appropriate sentence on 12 of 1152 trials (varying between 0 and 3 times in the eight different experimental conditions). From the remaining 1140 sentences, the percentages of sentences subjects wrote with full relative clauses as a function of ambiguity and plausibility are shown in Figure 2. In Experiment 3, the ambiguity of the past-participle marking had virtually no effect on whether subjects included full relative clauses in their sentences: Subjects wrote full relative clauses 0.4% more often in sentences including ambiguous past-participle verbs (bottom bars; 61.1%) compared to in sentences including unambiguous past-participle verbs (top bars; 60.7%). This difference was nonsignificant, $F(1, 47) < 1$, $CI = \pm 4.9\%$, $F(1, 23) < 1$, $CI = \pm 7.2\%$. Thus, Experiment 3 fails to support the suggestion that the difference due to past-participle ambiguity in the predicted direction in Experiment 1 indicated any real effect of past-participle ambiguity on full-relative use.

Plausibility, in contrast, marginally affected full relative-clause use. Subjects wrote full relative clauses 4.8% more often in sentences with agent-plausible main subjects (white bars; 63.2%) compared to in sentences with patient-plausible main subjects (dark bars; 58.5%). This difference was marginally significant by subjects and sentences, $F(1, 47) = 3.28$, $p < .08$, $CI = \pm 5.3\%$, $F(1, 23) = 3.99$, $p < .06$, $CI = \pm 5.1\%$. Thus, subjects showed a moderate tendency toward using full relative clauses in sentences with real-world pragmatics that made the subject-verb sequence seem more interpretable as a subject-main-verb sequence.

If subjects were sensitive to the joint effect of verb ambiguity and plausibility, then the plausibility effect should be qualified by the ambiguity of the past-participle marker, such that the plausibility difference is larger with ambiguous past participles than with unambiguous past participles. As shown in Figure 2, however, this pattern is (if anything) the opposite: Numerically, subjects wrote more full relative clauses with agent-plausible main subjects than with patient-plausible main subjects (by 8.7%) only when the sentence had an unambiguous past-participle marker. When the sentence had an ambiguous past-participle marker, the plausibility difference was

much smaller (0.9%). This interaction was unanticipated and is difficult to interpret, and indeed, it was nonsignificant by sentences, $F(1, 47) < 1$, $CI = \pm 14.1\%$, $F(1, 23) = 4.09$, $p < .06$, $CI = \pm 5.9\%$. Thus, the plausibility effect is likely independent of the ambiguity manipulation, suggesting that to the extent that subjects were sensitive to plausibility at all, it was independent of the ambiguity of the past-participle marker. Thus, as observed statistically in Experiment 1, subjects are insensitive to verb ambiguity, both overall and in terms of its joint influence on ambiguity with plausibility.

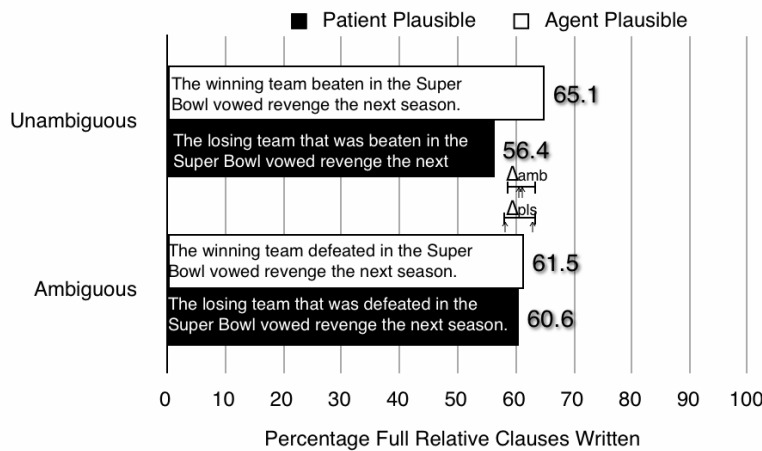


Figure 2. Percentages of full relative clauses written for sentences with unambiguous and ambiguous past-participle verbs and main subjects that were plausible agents or patients of relative-clause verbs. Error bars illustrate 95% confidence interval of the main effect differences, with arrows on error bars indicating main effects means.

The merely marginal significance of the plausibility main effect may cause some concern. To investigate this effect further, an analysis was conducted on the relationship between the use of full-relative clauses by Experiment 3 subjects and the offline normative ratings provided by the independent group of subjects (see the Method section of Experiment 3). If plausibility truly affected the use of full relative clauses, then those subject-verb sequences that had more positive agent advantages should have been written with full relative clauses more often than those subject-verb sequences that had more negative agent advantages. Indeed, this was so: When collapsed across the plausibility and past-participle ambiguity factors, the proportion of full relative clauses subjects used correlated positively with agent advantage, $r = .223$, $p < .03$. Thus, though the categorical measure of subject-verb plausibility

shows just a marginal effect of plausibility upon full relative clause use, a more continuous measure of subject-verb plausibility shows the expected pattern more robustly (more full relative clauses with subject-verb combinations that seem more like agents). That said, a correlation of .223 is modest, and so the effect of plausibility, though significant, should be cautiously interpreted.

Subsidiary analyses revealed a reversed effect of whether sentences were originally presented in full or reduced form: Subjects were 16.4% more likely to write full relative clauses for sentences that were originally presented in reduced form (69.1%) compared to sentences originally presented in full form (52.7%), $F(1, 47) = 13.9$, $CI = \pm 8.8\%$, $F(1, 23) = 42.1$, $CI = \pm 5.2\%$. Though unanticipated, this effect suggests that subjects had no tendency to be

inertial with their writing, preserving the form they were originally presented with. (If anything, subjects were “know it alls,” changing sentences more often than they left them alone. It may be that they took the rewrite instructions to imply that most sentences should be changed.) Reduction showed a weak tendency to interact with ambiguity, $F(1, 47) = 2.88, p < .10, CI = \pm 7.6\%$, $F(1, 23) = 5.51, p < .05, CI = \pm 13.8\%$, though not in any theoretically anticipated manner (with about a 5% positive ambiguity effect with sentences originally presented with full relative clauses, but a 4% reversed ambiguity effect with sentences originally presented with reduced relative clauses).

General discussion

Summarizing the whole pattern: When given sentences, told how to modify them, and instructed to modify them to make them easier to understand, subjects did not reliably avoid ambiguities created when sentences included verbs with ambiguous versus unambiguous past-participle markers. In contrast, they showed a moderate tendency toward including full relative clauses whenever sentences included a subject-verb combination that (incorrectly) could be interpreted as plausible main-subject-main-verb sequences. This tendency to use full relative clauses with plausible main-subject-main-verb sequences was not sensitive to ambiguity as conditioned by the verb’s past-participle marker: When a subject-verb sequence was a plausible main-subject-main-verb sequence but nonetheless included a disambiguating past-participle verb, subjects still wrote sentences more often with full relative clauses (if anything, doing so more with sentences that had unambiguous rather than ambiguous verbs). Finally, a separate group of writers who were given the potentially ambiguous fragments tested in Experiment 1 showed a strong tendency to complete fragments with main-verb continuations rather than passive relative-clause ones, suggesting that ambiguous sentence forms were indeed likely to cause disruptive garden-path effects.

These results constrain the interpretation of existing data and future claims of ambiguity avoidance. Specifically, they place limiting conditions on the kinds of ambiguity that speakers are likely to be sensitive to. Here, subjects were shown how they could modify their sentences and they were given a clear and (if you will) unambiguous mandate to make their sentences “easier to understand” (which, though not directly about ambiguity, is likely more understandable to those who are not experts about

language). Even so, if anything, subjects were sensitive to ambiguity only as influenced by their real-world knowledge; they were clearly not sensitive to ambiguity as influenced by the morphological details of their utterances.

This overall pattern fits well with results revealed by Ferreira et al. (2005). As briefly mentioned above, in that report we showed that when speakers were asked to disambiguate targets that were linguistically ambiguous (due to *homophony*, by describing a flying-mammal bat in the context of a baseball bat), they did so weakly and inconsistently. But when speakers were asked to disambiguate targets that were nonlinguistically ambiguous (due to category overlap, by describing a smaller flying-mammal bat in the context of a larger flying-mammal bat), they did so robustly and consistently. Past-participle ambiguity, as a morphological factor, is a form of linguistic ambiguity. Plausibility, as a factor based on real-world knowledge, is closer to nonlinguistic ambiguity (even though technically, its influence here is upon a linguistic ambiguity). Thus, just as in Ferreira et al. (2005), speakers were more sensitive to nonlinguistic factors that influence ambiguity than to linguistic factors that influence ambiguity.

As discussed in Ferreira et al. (2005), the differential sensitivity to these forms of ambiguities follows from the architecture of production. Speakers begin utterance planning with conceptual knowledge, crafting in terms of their real-world knowledge the meaning to express. Linguistic formulation processes then attempt to encode the crafted meaning into a set of linguistic features. Real-world knowledge is thus available to influence the initial stages of utterance planning in a way that a linguistic property is not.

It is important to emphasize, however, that the present results were based on performance in this ‘copy-editor task,’ and thus may or may not reveal the operations of mechanisms that underlie more extemporaneous production. Especially important is that the instructions to read, evaluate, and rewrite sentences likely placed a heavy burden on *monitoring* processes -- processes which inspect and evaluate pre- or post-articulatory linguistic forms for their communicative adequacy. As such, these results suggest that when speakers bring all of their utterance-crafting skills to bear on formulating an expression, including their production and monitoring skills, morphological ambiguity does not affect formulation, and plausibility might. In short, these results reveal what speakers are in principle

capable of, not what they or their production mechanisms typically do.

The present results also demonstrate an interesting decoupling of the vulnerabilities of readers and the predilections of writers. Past research has revealed that readers indeed find sentences with unambiguous past-participle verbs easier to understand (Trueswell et al., 1993), and that plausibility influences comprehension performance only when other factors do not disambiguate structures instead (Garnsey et al., 1997). Furthermore, the sentence completions described in Experiment 2 confirm that the ambiguous sentences tested here were likely to give rise to temporary ambiguity. Even so, writers in the copy-editor task were insensitive to past-participle ambiguity, but seemed sensitive to plausibility regardless of whether other factors disambiguated structures. This decoupling of comprehension vulnerabilities and production performance is interesting theoretically, as it suggests that production patterns cannot come entirely from comprehension patterns (or vice versa). Given that speakers *are* comprehenders, this implies that production processes do not have access to the difficulty that comprehension processes undergo, even within the same overall language-processing system. This decoupling is also interesting practically: The job of real-world copy editors is to tweak sentences so as to make them easier for readers to understand. The present results suggest that naive copy editors, at least, may not have access to all of the ambiguity-relevant factors that make sentences harder or easier to understand.

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