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AN EXPERIMENTAL INVESTIGATION
OF SYNTACTIC SATIATION
EFFECTS

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It is often reported anecdotally that over time, certain types of sentences that were initially judged ungrammatical begin to sound increasingly acceptable. This phenomenon is sometimes referred to as “linguists’ disease,” or a “syntactic satiation effect.” Indeed, many linguists admit that they can no longer perceive the (presumed) ungrammaticality of certain syntactic violations and that they have simply memorized the judgments that are standard in the linguistics literature.

Pursuing a line of inquiry initiated in Stromswold 1986, this study examines whether syntactic satiation effects can be induced experimentally. Moreover, the study addresses the following key questions: Is syntactic satiation found to a comparable degree for all ungrammatical sentence types, or are there specific types of ungrammatical sentences that are especially susceptible? In the latter case, which types of violations “sate” most easily? Finally, does syntactic satiation “carry over” when lexical items are changed, or is it lexically specific?¹

1 Method

Subjects (22 paid MIT undergraduates) were asked to provide a yes/no judgment of grammaticality for a series of 58 sentences, presented

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¹ For a comprehensive review of psycholinguistic research on grammaticality judgments, see Schutze 1996.

sequentially, one item per page, in a printed questionnaire. Each item consisted of a “context” sentence, describing a particular situation, and then a test sentence, always in the form of a *wh*-question about the preceding situation. An example is provided in (1).²

- (1) *Context*
 Maria believes the claim that Beth found a \$50 bill.
Test sentence
 “What does Maria believe the claim that Beth found?”
Judgment
 _____ (Y/N)

The questionnaire included 4 practice items, 50 experimental items, and a 4-item post-test. Experimental items were randomly arranged into five blocks, each containing 3 fully grammatical items and one each of 7 mildly-to-severely ungrammatical sentence types. The ungrammatical sentence types are listed with examples in (2).³

- (2) a. *Want-for*
 Who does John want for Mary to meet (t)?
 b. *Whether-island*
 Who does John wonder whether Mary likes (t)?
 c. *That-trace*
 Who does Mary think that (t) likes John?
 d. *Subject island*
 What does John know that a bottle of (t) fell on the floor?
 e. *Complex NP*
 Who does Mary believe the claim that John likes (t)?
 f. *Adjunct island*
 Who did John talk with Mary after seeing (t)?
 g. *Left branch*
 How many did John buy (t) books?

Forward/backward presentation of the 50-item stimulus list was balanced across subjects. The subjects were instructed to ignore the fact that many of the test sentences would be similar, to refrain from turning back or attempting to remember judgments given on previous sentences, and simply to give their first reaction before moving on.

² Pilot work suggested that for detecting satiation in nonlinguists, a yes/no judgment task would be superior to a numerical rating scale. Subjects in pilot work reported confidence in distinguishing between grammatical and ungrammatical sentences, but difficulty in assigning a numerical rating to a “degree” of ungrammaticality. Indeed, when judging a *that*-trace violation, one subject reported that she was deducting only “one point,” because only one word (*that*) was incorrect. Use of a yes/no task reduces the noise expected from idiosyncratic rating strategies.

³ Most of the sentence types in (2) have been topics of investigation since the 1960s. The complex-NP and left-branch effects were first characterized by Ross (1967), who also noted examples of (what are here termed) *whether*-islands (1967:16–17) and subject islands (1967:145, n. 31). An early discussion of the *that*-trace effect appeared in Perlmutter 1968 (see also Perlmutter 1971: 108). Examples of the *want-for* effect were noted in Rosenbaum 1967:66–67.

On the basis of anecdotal reports, *whether*-islands and complex-NP effects were predicted to be subject to syntactic satiation. *That*-trace effects and left-branch effects were predicted *not* to be subject to satiation. No specific predictions were made for the remaining ungrammatical sentence types.

The experimental items for *whether*-islands all used the verb *wonder*, and the items for complex-NP violations all used the phrase *believe the claim*. A post-test was included at the end of the questionnaire to determine whether any observed satiation extended beyond these particular lexical items. The four-item post-test included one *whether*-island item using the matrix verb *ask* and one complex-NP item using the phrase *accept the idea*. The remaining two items were grammatical fillers.

2 Results

In the initial analysis of the resulting data, syntactic satiation was measured for each sentence type by comparing, for each subject, the number of *yes* responses in the first two blocks to the number of *yes* responses in the last two blocks. A *subject* was considered to have exhibited satiation for a given sentence type if the number of *yes* responses in the last two blocks exceeded the number in the first two blocks. A *sentence type* was said to have exhibited satiation if the number of subjects showing an increase in *yes* responses (i.e., satiation) was significantly greater, by sign test, than the number of subjects showing a decrease in *yes* responses.⁴

As predicted, significant satiation effects were obtained for *whether*-islands (11 N → Y, 1 Y → N, $p = .003$ by sign test) and for complex-NP violations (5 N → Y, 0 Y → N, $p = .031$ by sign test). The fact that the materials were balanced across subjects for forward/backward order of presentation indicates that these effects cannot be attributed to absolute differences in the acceptability of particular items. Also as predicted, *no* significant satiation effects were obtained for left-branch violations (1 N → Y, 0 Y → N, $p = .500$ NS by sign test) or *that*-trace violations (2 N → Y, 3 Y → N, $p = .500$ NS by sign test). Of the remaining ungrammatical sentence types, none showed a significant satiation effect (adjunct islands: 3 N → Y, 1 Y → N, $p = .312$ NS by sign test; *want-for*: 4 N → Y, 4 Y → N, $p = .637$ NS by sign test), although a marginally significant preponderance of “No-to-Yes” response patterns for subject islands is suggestive (subject islands: 9 N → Y, 3 Y → N, $p = .073$ by sign test).

A possible concern about the use of sign tests is that it abstracts away from much of the variability in the data. Subjects whose *yes*

⁴ Thus, in this analysis satiation is operationally defined by comparing two pairs of instances of each sentence type. Scenarios classified as a “No-to-Yes” change (consistent with satiation) are 0 → 1 (zero *yes* responses in blocks 1–2, one *yes* response in blocks 4–5), 0 → 2, and 1 → 2. Classified as a “Yes-to-No” change are 2 → 1, 2 → 0, and 1 → 0.

responses were evenly distributed across the beginning and the end of the questionnaire are necessarily excluded from a sign test analysis. Further, each sign test focuses on an individual sentence type, without reference to the data for other sentence types.⁵

To address these concerns, the data were subjected to two additional statistical tests. First, a paired *t*-test was performed on each sentence type, comparing the number of *yes* responses from each subject at the beginning (blocks 1–2) with the number at the end (blocks 4–5). Unlike the sign test analysis, this procedure includes the data from every subject. Second, a one-way repeated-measures analysis of variance (ANOVA) was performed on the difference scores obtained (for any given subject, on any given sentence type) by subtracting the number of *yes* responses at the beginning (blocks 1–2) of the questionnaire from the number at the end (blocks 4–5). This technique permits a direct comparison across the different sentence types. If the interpretation of the sign test analysis is correct, and acceptance rate increases only for a proper subset of the ungrammatical sentence types (*whether*-islands, complex-NP violations, possibly subject islands), then we predict a significant effect of sentence type on the difference scores.

The results of both procedures generally support the findings of the sign test analysis. In paired *t*-tests, a significant increase in *yes* responses was again obtained for *whether*-islands ($t(21) = 3.521, p = .002$) and for complex-NP violations ($t(21) = 2.485, p = .021$). A marginally significant increase was also observed for subject islands ($t(21) = 1.789, p = .088$), whereas no significant increase was detected in left-branch violations ($t(21) = 1.000, p = .329$), *that*-trace violations ($t(21) = 0.439, p = .665$), adjunct islands ($t(21) = 0.439, p = .665$), or *want-for* violations ($t(21) = 0.237, p = .815$).

Also as predicted, the repeated-measures ANOVA detected a significant effect of sentence type on difference scores ($F(6, 126) = 3.277, p = .005$).⁶ Application of Tukey's Method revealed significant ($p < .05$) pairwise contrasts between *whether*-islands and each of *that*-trace, *want-for*, left-branch, and adjunct island violations. Complex-NP violations and adjunct islands, however, were assigned an intermediate status by the Tukey procedure, as they failed to contrast significantly either with *whether*-islands or with the remaining (nonsatiating) sentence types.

Results from the post-test were analyzed for a possible carryover effect of satiation across lexical items. Analysis focused on subjects who initially rejected *whether*-islands with the matrix verb *wonder*. These subjects were first classified as satiating or not satiating on

⁵ I am grateful to an anonymous *LI* reviewer for calling these issues to my attention.

⁶ Application of Friedman's Repeated-Measures ANOVA (a nonparametric counterpart to the standard one-way repeated-measures ANOVA) also detected a significant effect of sentence type ($\chi^2(6) = 16.338, p = .012$).

whether-islands by the end of the experiment, and were then cross-classified as accepting or rejecting the post-test item containing a *whether*-island violation with matrix verb *ask*. The rate of acceptance of the post-test item among subjects who consistently rejected the *whether*-item was calculated as a baseline measure. A binomial test (modified sign test) was then applied to find the probability of obtaining, simply by chance, such a high acceptance rate for the post-test item among subjects who had satiated during the experiment, under the null hypothesis that these subjects generally have the same probability of accepting the post-test item as subjects who do not satiate. The same procedure was applied to subjects who initially rejected complex-NP violations with *believe the claim*, to test for carryover of satiation to complex-NP violations with *accept the idea*.

Acceptance of the post-test item with *ask whether* was significantly more frequent than would be expected by chance, among subjects who had satiated on experimental items with *wonder whether* (acceptance by nonsatiators = 4/17; acceptance by satiators = 4/5; binomial $p = .019$). Likewise, acceptance of the post-test item with *accept the idea* was significantly more frequent than would be expected by chance, among subjects who had satiated on experimental items with *believe the claim* (acceptance by nonsatiators = 3/7; acceptance by satiators = 10/11; binomial $p = .013$).

Finally, to test whether the satiability of a sentence type corresponded to its initial acceptability, an additional 10 subjects were recruited and asked to complete the questionnaire using a numerical rating system in place of yes/no judgments. The scale ranged from 0 for a completely ungrammatical sentence, to 5 for a fully grammatical sentence. The ratings provided in the first block (following practice items) were then averaged across subjects. Results indicated that on first exposure, *want-for* items (with an average rating of 4.15) were the most nearly acceptable of the ungrammatical items, followed by *whether*-islands (3.35), *that*-trace violations (2.95), subject islands (2.60), complex-NP violations (1.90), adjunct islands (1.65), and finally left-branch violations (1.05). Thus, the satiability of a sentence type does not appear to correspond in any simple way to its initial acceptability: the sentence types exhibiting significant satiation, *whether*-islands and complex-NP violations, were dissimilar in their numerical ratings, and neither of them fell at an extreme end of the scale.⁷

3 Conclusions

The results of this study indicate that syntactic satiation effects can be induced experimentally, in the laboratory. Moreover, the effects

⁷ Note that nonsatiating sentence types of intermediate acceptability, such as *that*-trace violations, were associated with mixed *yes* and *no* responses (vacillation), but the *yes* responses were fairly evenly distributed over the questionnaire.

induced in the study were specific to certain sentence types, corresponding closely to those sentence types for which satiation has been reported anecdotally. Thus, satiation is not an across-the-board phenomenon affecting all sentence types equally.

Additionally, the results of the post-test indicate that the satiation effects observed in this study were not tied to specific combinations of lexical items such as *wonder whether* or *believe the claim*. Hence, it does not appear that syntactic satiation is simply the result of learning a new idiom chunk or a reanalyzed predicate (e.g., learning *believe the claim* as a lexical variant of the verb *believe*).

Furthermore, susceptibility to satiation does not correspond closely to points of crosslinguistic variation. For example, the left-branch effect appears to be inoperative in many languages (see, e.g., Uriagereka 1988, Corver 1990), but English sentences that are ungrammatical by virtue of this effect show no sign of satiation, either in the present experimental study or in anecdotal reports of linguists' disease. Likewise, the *that*-trace effect is subject to cross-dialectal variation (*that*-trace violations are fully grammatical for some English speakers; see Sobin 1987), yet it did not exhibit satiation within the experiment. Again, this result conforms well to the anecdotal reports of linguists' disease solicited by the author; linguists retain a percept of strong ungrammaticality for *that*-trace violations even when *whether*-islands and complex-NP violations have lost their force.

The "satiability" of the classic subadjacency effects—namely, the *wh*-island effect and the complex-NP effect—indicates a different grammatical status from the adjunct island effect, *that*-trace effect, left-branch effect, and *want-for* effect.⁸ One possibility is that the satiable effects reflect limitations of sentence processing, rather than genuine constraints of the speaker's grammatical competence (cf. Chomsky's (1965:10–14) discussion of center embedding). Such a view would be consistent with certain versions of Berwick and Weinberg's (1984:153–173) proposal that subadjacency effects are ultimately due to computational constraints on human sentence processing. For example, on the basis of evidence from evoked response potentials (ERP), Kluender and Kutas (1993) have argued for an especially strong version of Berwick and Weinberg's proposal in which the unacceptability of subadjacency violations follows directly from the operation of the sentence processor, and the competence grammar itself does not exclude subadjacency violations.

Alternatively, the satiability of an island effect may reflect its membership in a distinctive subclass of constraints within the compe-

⁸ The susceptibility of subject islands remains unclear in the present study. Hiramatsu (1998) has replicated the key findings of the present study and concludes that subject islands do exhibit satiation; she also discusses the fact that the contrast between subject islands (satiating) and adjunct islands (nonsatiating) is problematic for most approaches to island effects within the principles-and-parameters and minimalist frameworks, including the approaches taken in Huang 1982, Chomsky 1986, and Takahashi 1994.

tence grammar. On this view, “satiating” versus “nonsatiating” might be taken as one particular dimension along which the percept of ungrammaticality varies, comparable to the dimension of “strength of ungrammaticality” (/?/?/?/*/?/*/*/*).

Independently of whether satiable violations in fact reflect constraints of grammar or of sentence processing, evidence from experimental studies of satiation could prove useful when judging whether theoretical unification should be attempted for two disparate constraints. For example, a *that*-trace configuration and a *whether*-island configuration both lead to initial judgments of moderate ungrammaticality, according to the numerical ratings collected as part of the present study. Hence, a syntactician might reasonably seek to account for both effects by proposing a single syntactic principle P, where both the *that*-trace configuration and the *whether*-island configuration violate (only) P, and any violation of P results in the perception of moderate ungrammaticality.

Yet the satiation data from the present study speak against such an analysis, because we have seen that after repeated exposure (both in the present study and according to linguists’ self-reports), the *whether*-island configuration is commonly perceived to be nearly or fully grammatical, whereas the *that*-trace configuration continues to be perceived as moderately ungrammatical. If the perception of ungrammaticality in the two sentence types had a common source (P), we would expect their perceived grammatical status to covary; in particular, a satiation effect for *whether*-islands, and hence for P, is predicted to carry over automatically to *that*-trace violations. Refutation of this prediction, as in the present study, therefore indicates that the (grammatical or processing) constraint responsible for *that*-trace effects cannot be identical to the constraint responsible for *whether*-islands. Given that only one of the two constraints is susceptible to satiation, any attempt at unification appears untenable.

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