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BOUNDED PROJECTION: THE EFFECT OF PROSODIC PHRASING ON FOCUS INTERPRETATION

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0. Introduction[1]

It is well-known from studies of languages other than English that focus can affect the grammatical possibilities of prosodic phrasing for an utterance. I argue here, based on the results of a comprehension experiment for English, that the reverse can also hold true: the prosodic phrasing of an utterance can affect the interpretation of focus. Specifically, I claim that prosodic phrasing blocks the projection of focus, limiting focus to material in the prosodic phrase which contains the focusing pitch accent. I shall refer to this as the *bounded projection* effect.

The bounded projection effect may appear to be a counterexample to a phonological analysis such as in Truckenbrodt (1995) that claims there is no direct connection between focus and prosodic phrasing. However, I show that the comprehension facts can be accounted for through a parsing explanation and thus do not necessarily challenge his grammatical analysis.

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I further show that the bounded projection effect falls out from independently motivated parsing principles if we employ a model of sentence comprehension which makes use of the prosodic hierarchy, but that the bounded projection effect is not easily accounted for under different assumptions about the role of prosody in sentence comprehension.

1. Phonological Background

I will employ a prosodic hierarchy for English in which each utterance is composed of one or more intonational phrases, each intonational phrase is composed of one or more intermediate phrases and ends with a high or low boundary tone (H% or L%), each intermediate phrase contains one or more pitch accents and ends with a high or low phrase accent (H- or L-), and pitch accents can be high (H*), low (L*), or a combination of high and low (e.g., L+H*) (Pierrehumbert 1980, Beckman & Pierrehumbert 1986, Pierrehumbert & Beckman 1988).

I will assume that arguments which present new information must be accented (Selkirk 1984) with an appropriate pitch accent (Pierrehumbert & Hirschberg 1990), such as an H*. I will also follow Selkirk's theory of focus projection (1984, 1995). In this theory, accented words are *F-marked*. F-marking can project from internal arguments to heads, from heads to phrasal nodes, and from NP- and *wh*-moved elements to their traces. The focus of a sentence is the F-marked constituent which is not dominated by any other F-marked constituent (1995 pp. 555, 561). Thus, production (1a), in which capitalization marks an H* pitch accent, can have focus as marked in (1b) - (1e), in which the accented word *potatoes* is F-marked, and the F-marking optionally projects to the NP, VP, or sentence.

(1) Focus Projection:
- a. The farmer delivered some POTATOES.
- b. The farmer delivered some $[\text{potatoes}]_{FOC}$
- c. The farmer delivered $[\text{some potatoes}]_{FOC}$
- d. The farmer $[\text{delivered some potatoes}]_{FOC}$
- e. $[\text{The farmer delivered some potatoes}]_{FOC}$

2. Prosodic Phrasing and Focus

There are languages which require that a prosodic phrase be associated with focus. For example, in Chichewa (Kanerva 1990) the neutral phrasing of a VP, given in (2a), has just one prosodic phrase (marked with parentheses), but utterances of the VP with contrastive focus require a prosodic phrase break at the right edge of the focus, as shown in (2b - 2d). Other languages which require a prosodic phrase break at the edge of a

focused constituent include Bengali (Hayes & Lahiri 1991), Korean (e.g., Jun 1993), and Japanese (e.g., Nagahara 1994).

(2) The Effect of Focus on Phrasing in Chichewa:
- a. (Anaménya nyumbá ndí mwalá)
  hit house with rock
  'He hit the house with a rock'
- b. (Anaménya nyumbá ndí $[\text{mwalá}]_{FOC}$)
  'He hit the house with $[\text{a rock}]_{FOC}$'
- c. (Anaménya $[\text{nyumbá}]_{FOC}$) (ndí mwalá)
  'He hit $[\text{the house}]_{FOC}$ with a rock'
- d. ($[\text{Anaménya}]_{FOC}$) (nyumbá) (ndí mwalá)
  'He $[\text{hit}]_{FOC}$ the house with a rock'

English does not seem to require a prosodic phrase break at either the left or right edge of a focused constituent. Thus the sentence in (3), with narrow focus on *delivered*, is well-formed when produced as a single prosodic phrase, as in (3a), or when produced with a prosodic break at the left edge of the focus, as in (3b); at the right edge, as in (3c); or with breaks at both edges, as in (3d).

(3) Phrasing Options for Focus in English:
- a. (The farmer $[\text{DELIVERED}]_{FOC}$ some potatoes)
- b. (The farmer) $([\text{DELIVERED}]_{FOC}$ some potatoes)
- c. (The farmer $[\text{DELIVERED}]_{FOC}$) (some potatoes)
- d. (The farmer) $([\text{DELIVERED}]_{FOC}$) (some potatoes)

However, example (4) shows that prosodic phrasing and focus do interact in English. The response in (4), with accents on the subject and object, no accent on the verb, and a prosodic phrase break before the object, is intuitively unnatural as an answer to a VP-focus question. Example (5) shows that there is nothing inherently unnatural about the phrasing, as it is fine with an object-focus question.[2]

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[2] Steedman (1991), working within Categorial Grammar (see his paper for details), notes the intuitive difference in acceptability between sentences like (4) and (5). He provides an account which can correctly rule out (4) and allow (5) but incorrectly allows question (i) to be answered with the contour in (ii) when the verb presents new information. Further, his system uses a reduced accent and tone inventory which, for example, incorrectly excludes the use of L+H* accents to mark new focal information. Thus, the article does not seem to provide a general account of focus and phrasing patterns in English.

(i) What happened to the potatoes?

H* L- L+H* L-L%
(ii) (The farmer delivered) (the potatoes)

(4) What did the farmer do?
(The farmer delivered) (some POTATOES)

(5) What did the farmer deliver?
(The farmer delivered) (some POTATOES)

Examples (3) through (5) show that although in English the focus does not need to be identical in span to a prosodic phrase or align with either edge of a prosodic phrase, it nevertheless cannot extend beyond the edge of a prosodic phrase to include unaccented material. These facts suggest the Bounded Projection Hypothesis (BPH), given in (6). Sample predictions of the BPH for a sentence produced with an H* accent on the object and no accent on the verb are given in (7).

(6) Bounded Projection Hypothesis:
F-marking cannot project beyond the prosodic phrase which contains the accented material.

(7) Sample predictions of the BPH:
a. (The farmer delivered) (some [POTATOES]$_{FOC}$)
b. (The farmer delivered) ([some POTATOES]$_{FOC}$)
c. * (The farmer [delivered) (some POTATOES]$_{FOC}$)
d. * ([The farmer delivered) (some POTATOES]$_{FOC}$)

3. A Bounded Projection Experiment

3.1 Materials, Design, and Method

The Bounded Projection Hypothesis was tested in a sentence comprehension experiment in which subjects rated the naturalness of question-answer pairs. The experiment included two kinds of questions, a VP-focus question (e.g., *What did the farmer do?*) and an object-focus question (e.g., *What did the farmer deliver?*). This allowed comparison of the naturalness ratings for question-answer pairs like (4) and (5), which differ in predicted naturalness for answers with identical prosody.

There were three kinds of answers in the experiment, differing only in prosody. The three answers were fully crossed with the two questions, creating six experimental conditions. A sample set is given in (8). Detailed information on the prosody of the answers is provided in Appendix A.

The first kind of answer, the *object-phrasing* answer (8 a,b), was as in (4) and (5). It was composed of two prosodic phrases. The first prosodic phrase contained the subject and verb, and the second prosodic phrase contained the object. The sentence contained an L* accent on the subject, no accent on the verb, and an H* accent on the object. Since there was no accent on the verb, VP-focus required the projection of F-marking from the accented object to the verb and then to the VP. The BPH predicts that

such projection is impossible in this case, though, because the verb and VP-node are in a separate prosodic phrase from the object. However, object-focus is predicted to be possible for this prosody, because the F-marking does not need to project beyond the prosodic phrase containing the object. Thus, the BPH predicts that condition (a), with an object-focus question and an object-phrasing answer, should be judged as natural, but condition (b), with a VP-focus question and an object-phrasing answer, should be judged as unnatural.

In the second kind of answer, the *VP-phrasing* answer (8 c,d), the accents were the same as in the object-phrasing answer: L* on the subject, no accent on the verb, and H* on the object. The VP-phrasing answer differed from the object-phrasing answer only in the prosodic phrasing. The first prosodic phrase contained the subject, and the second prosodic phrase contained the verb and object. With this prosody, the verb is in the same prosodic phrase as the accented material, so under the BPH both object-focus and VP-focus should be possible. Thus, the BPH predicts that condition (c), with an object-focus question and a VP-phrasing answer, and condition (d), with a VP-focus question and a VP-phrasing answer, should both be judged as natural. By including these two conditions any basic differences in judged naturalness between question-answer pairs with VP-focus questions and those with object-focus questions could be separated from any effects of bounded projection.

The third kind of answer, the *control* answer (8 e,f), contained accents which were inappropriate for the information structure of the sentence, so it provided an unnatural response to each of the questions. As in the VP-phrasing answer, the subject formed the first prosodic phrase and the verb phrase formed the second one, but the accents in second prosodic phrase differed: in the control answer the verb received an L+H* accent and the object was unaccented. Because the object presented new information in all of the experimental sentences, it was expected that the lack of accent on the object in this contour would cause both the object-focus question-answer pair (condition (e)) and the VP-focus pair (condition (f)) to be judged as unnatural.[3] Because they had VP-phrasing, conditions (e) and (f) also served to prevent the subjects from associating unnaturalness with the object-phrasing found in the condition predicted to be unnatural by the BPH. The predictions for all of the conditions are summarized in the table in (9).

(8) Sample Set of Materials:
a. What did the farmer deliver?
(The farmer delivered) (some POTATOES)

b. What did the farmer do?
(The farmer delivered) (some POTATOES)

[3] Condition (e) was also unnatural because of the presence of accent on the verb, as the verb presented non-contrastive given information.

presented out of context. The reaction time results from that experiment suggest that the object-phrasing answer may have been more natural or easier to process than the VP-phrasing answer, but they confirm that the control answer was not inherently less natural than the others. Thus, the low ratings in the bounded projection experiment for the control answer (conditions (e) and (f)) provide further experimental evidence that accenting old, non-contrastive information and failing to accent new information is unnatural. This is consistent with other studies in the literature on the effect of accent placement on information structure (Bock & Mazzella 1983, Nooteboom & Kruyt 1987, Terken & Nooteboom 1987, Eefting 1992).

Second, and more importantly, these results strongly support the Bounded Projection Hypothesis. The significant interaction of question-type and phrasing in the bounded projection experiment shows that the prosodic phrasing affected the interpretation of focus. The pairwise comparisons show that the object-phrasing answer was significantly less natural as an answer to a VP-focus question than an object-focus question, but a VP-phrasing answer was not significantly different in naturalness for the two kinds of questions. That is, the naturalness judgment was significantly lower only for the case in which F-marking had to project outside of a prosodic phrase, as predicted by the BPH.

These results demonstrate that the interpretation of focus in English is influenced prosodically not just by the presence or absence of pitch accents but by the pattern of accentuation and phrasing in the utterance. This finding has important consequences for psycholinguistic research as well as formal linguistic research. Regarding psycholinguistics, this work shows that the parser must somehow make use of prosodic phrasing information and accent information together, supporting models which make use of the prosodic hierarchy over models which segregate prosodic phrasing from accents. This will be discussed further in the next section.

As for formal linguistics, the results point out potential complications for work on focus within syntax and semantics. Whenever a syntactic structure is obligatorily associated with a prosodic break (e.g., for parentheticals, appositives, or gapping structures), focus should be unable to project beyond these breaks. The projection of focus should also be blocked in sentences which require a prosodic break because of their length (Gee & Grosjean 1983). Thus, in some sentences it may not be possible to determine whether syntactic factors directly limit focus, because they are confounded with prosodic factors.

The results also pose an apparent challenge to a recent proposal by Truckenbrodt (1995) that there is no direct connection between focus and prosodic phrasing (in the grammar). Truckenbrodt shows that the effects of focus on phrasing in Chichewa, Chi Mwi:ni, Kimatuumbi, and Japanese can be captured through Optimality Theoretic constraints which connect prominence with focus, prosodic structure, and syntactic structure and connect prosodic structure and syntactic structure but do not directly connect focus and prosodic phrasing.

The bounded project effect is not accounted for under such a set of constraints. The constraints give each answer identical violations under the two focus conditions, so any ranking which rules out object-phrasing with VP-focus also rules out object-phrasing with object-focus. Full discussion of this is beyond the scope of this paper; see Schafer (in preparation) for further analysis. However, in the next section I will show that the bounded projection effect can be accounted for by principles of sentence processing and therefore need not be seen as a counterexample to Truckenbrodt's proposal.

4. Analysis

It may seem unlikely that there could be a parsing explanation for the bounded projection effect. Though the psycholinguistic literature has shown that differences in accent placement can affect the interpretation of information structure (Bock & Mazzella 1983, Nooteboom & Kruyt 1987, Terken & Nooteboom 1987, Eefting 1992), the crucial conditions in the bounded projection experiment did not differ in accentuation.

Further, studies on prosodic phrasing have generally shown that phrasing can be used to disambiguate between sentences with different syntactic bracketings but not between sentences with different syntactic labeling. For example, Lehiste (1973) found 87.9% correct identification of the intended meaning for sentence (12), which has bracketing differences, but only chance identification for sentence (13), with labeling differences.

(12) The old men and women stayed at home.

(13) Visiting relatives can be a nuisance.

In the cases when prosodic phrasing can disambiguate sentences, one generally finds larger prosodic breaks at the edge of larger syntactic constituents (Price et al. 1991). This cannot account for the bounded projection effect, because the phrase structure did not differ across the conditions. Nor is there evidence that listeners interpret the prosodic break as falling at the edge of the focused constituent. The naturalness rating for condition (c), with VP-phrasing and object-focus, was not significantly different than that of condition (d), in which the phrasing and focus coincided. Indeed, condition (c) was rated as more natural (numerically) than condition (d), not less, despite the mismatch between focus and phrasing. These conditions and their ratings are repeated in (14).

(14) Bounded Projection Conditions (c) and (d), and Their Ratings:

c.	(The farmer) (delivered [some POTATOES]$_{FOC}$)	3.2
d.	(The farmer) ([delivered some POTATOES]$_{FOC}$)	3.1

However, recent work in sentence processing on structures that do not involve focus has argued for syntactic node *visibility* as a factor in parsing decisions. I will argue that visibility extends naturally to account for the bounded projection effect. The Visibility

Hypothesis in (15) (Frazier & Clifton 1995) is based on intuitive evidence and experimental results from both visual and auditory studies on a range of structures.

(15) Visibility Hypothesis:
In first analysis and reanalysis, attachment to a visible node is less costly in terms of processing/attentional resources than attachment to a less visible node.
(i) Node X is more visible than node Y if X was postulated later than Y.
(ii) Nodes within a perceptually-given package (e.g., intermediate phonological phrase) are more visible than nodes outside the package.

One of these studies (Schafer 1995) was an auditory comprehension experiment on materials such as in (16), which were ambiguous between NP-attachment of the PP and the structurally-preferred VP-attachment of the PP. The sentences were produced with intermediate phrase breaks where indicated by parentheses. Subjects gave disambiguating responses to questions which followed the sentences; the percentage of VP-attachment responses is given after each sentence.

(16) Sample Materials and Percentage of VP-attachment Responses

a.	(The bus driver angered the rider) (with a mean look)	65%
b.	(The bus driver angered) (the rider with a mean look)	47%
c.	(The bus driver angered the rider with a mean look)	64%
d.	(The bus driver) (angered) (the rider) (with a mean look)	57%

The results support the hypothesis that attachment is affected by visibility as determined by prosodic phrases. In conditions (a) and (c), when the VP-node and NP-node are in the same prosodic phrase and are thus roughly equal in visibility to the parser at the point of the PP, the subjects followed the structural preference for VP-attachment. In condition (b), when the prosodic phrasing gives the NP-node sharply higher visibility than the VP-node, the percentage of VP-attachment responses decreased significantly, and in condition (d), with intermediate visibility of the NP-node compared to the other conditions, the percentage of VP-attachment responses was intermediate.

The bounded projection effect falls out from these independent assumptions on node visibility. In a sentence with an unaccented verb, VP-focus is only possible if F-marking projects from an F-marked argument of the verb to the verb and then to the VP-node. However, if the verb and VP-node are not in the same prosodic phrase as the F-marked material, these nodes will have low visibility at the point when the parser is processing the F-marked material. As in the attachment situation described above, in which phrases avoid attaching to low-visibility nodes, F-marking should avoid projection (or attachment of F-marking) to low-visibility nodes. Thus, focus is bound within the prosodic phrase which contains the accented material because it is unable to project to the low-visibility nodes of a previous prosodic phrase.

Accounting for the PP-attachment results and the bounded projection effect through visibility avoids a situation in which prosodic breaks seem to have at least three different effects on the parser. First, in the bounded projection experiment, a prosodic break constrained the interpretation of focus. Second, in conditions (a) and (d) of the PP-attachment experiment described above and in other cases in the literature (e.g., Price et al. 1991), a prosodic break resulted in the attachment of immediately following material to the higher of two potential attachment sites (e.g., PP-attachment to the VP-node instead of the NP-node.) Third, in conditions (b) and (d) of the PP-attachment experiment, a prosodic break seemed to have a non-local effect, inducing low attachment of material which did not immediately follow the break (i.e., a prosodic break before the NP induced low attachment of the PP.)

In contrast, under the visibility account, the parser interprets a prosodic break simply as the edge of a prosodic phrase. The prosodic phrasing determines visibility, and visibility constrains the possibilities for F-projection and attachment. Thus, an analysis which employs prosodic structure and visibility provides a unified account for what appears to be the disparate effects of prosodic breaks. Further, it does so in a theoretically-constrained fashion: all effects of prosody on sentence comprehension come from either general processing principles (such as visibility) or grammatical constraints on prosodic structure (such as those which provide the prosodic hierarchy.)

5. Conclusion

I have used the results of a comprehension experiment to argue that prosodic phrasing affects the interpretation of focus in English. The focus can span the same material as a prosodic phrase or be contained within a prosodic phrase, but it cannot extend to unaccented material which is outside of the prosodic phrase containing the focusing accent. I have further argued that this pattern can be accounted for by the independently-motivated processing principle of visibility.

The present analysis suggests many questions for further research. It makes some relatively detailed predictions, e.g. that the bounded projection effect is truly an effect of projection of F-marking, so there should be no dispreference for a VP-focus sentence with object-phrasing and an accented verb. It also makes more general predictions, e.g. that the effects of bounded projection will be found in any language which allows focus projection.

Perhaps the most interesting questions this work raises concern the nature of the relationship between grammatical constraints and sentence processing. For example, I have argued that the model of sentence comprehension is simpler if we assume that the parser interprets prosodic elements as part of a prosodic structure. In production, the possibilities and preferences for prosody with different kinds of focus constructions need further investigation. Although the effect of contrastive focus on prosodic phrasing has been described for several languages (see section 2), the patterns for broad versus narrow

focus and focus projection have not been widely studied. Thus, without knowing the constraints and constraint rankings -- or even the output candidates -- for these constructions in any language, it is not clear whether a processing explanation of the bounded projection effect can also simplify the grammar by rendering unnecessary any constraints which directly relate focus and prosodic phrasing.

Appendix A: Prosody of the Experimental Materials

The prosody of the experimental answers was analyzed by the author and three other researchers trained in ToBI transcription to verify that the prosodic breaks and accents occurred where intended and that the pitch accents of the object-phrasing answer and the VP-phrasing answer were the same. The author listened to and examined pitch tracks for all of the materials, one of the other researchers listened to and examined pitch tracks for a subset of the materials, and the remaining judges listened to all of the materials but did not look at pitch tracks.

All of the judges agreed that the control answer was as described in the body of the paper. They also agreed that the prosody of the object-phrasing answers and the VP-phrasing answers was identical except for the placement of the prosodic phrase break, that the verb was always unaccented, and that for all items the object carried an H* accent. Measurements confirmed that the object in the two answers did not differ significantly in duration (see (17) below) or peak F_0.[4]

The division into prosodic phrases was salient. Although the intonation contour did not show evidence for a boundary tone, the prosodic phrases were marked by lengthening of the preceding material and a pause. Pitch tracks for the object-phrasing and VP-phrasing answers consistently showed a rapid descent to a low on the primary stress of the subject. This low F_0 continued until the end of the first prosodic phrase, consistent with a leftward-spread L- phrase accent. In the second prosodic phrase the F_0 climbed to a high associated with the primary stress of the object and then fell to baseline.

The duration measurements suggest that the prosodic phrases were probably intonational phrases, given the amount of lengthening and the size of the pause. Mean durations for the subject, verb, object, and the pause between the prosodic phrases for the object-phrasing and VP-phrasing answers are given in (17). The differences between the answer types were significant for the subject ($t(23) = 8.09$, $p < .01$) and verb ($t(23) = 10.2$, $p < .01$) and consistent with phrase-final lengthening. The differences were not significant for the object or the pause.

[4] The mean peak on the object of the object-phrasing answer was 238 Hz; the mean peak on the object of the VP-phrasing answer was 239 Hz.

(17) Mean Durations, in ms.

	Subject	Verb	Object	Pause
Object-phr.	547	546	1025	370
VP-phrasing	717	417	1001	392

Overall, the materials were confirmed to have been produced as intended. The control answer contained a low accent on the subject, a contrastive accent on the verb, and no accent on the object. The object-phrasing and VP-phrasing answers contained a low accent on the subject, no accent on the verb, and a high accent on the object. The prosodic phrasing was similar in kind for all three answers and appropriately located, with a break occurring before the object for the object-phrasing answer and before the verb for the VP-phrasing and control answers.

Appendix B: List of Materials

A. Practice Items
1. Where's Mark? Mark is in the bathroom.
2. Where does Psych 115 meet? PSYCH 115 meets here.
3. Who ordered a pizza? BRIAN ordered a pizza.
4. Who cheated? Chris CHEATED!
5. What did Oscar eat? Oscar ate the lentil stew.

B. Experimental Items
1. What did Julie open/do? Julie opened a bakery.
2. What did the programmer discover/do? The programmer discovered a short-cut.
3. What did Emily design/do? Emily designed an evening gown.
4. What did the TA assign/do? The TA assigned a book report.
5. What did the farmer deliver/do? The farmer delivered some potatoes.
6. What did Molly clean/do? Molly cleaned the bathroom.
7. What did the treasurer of the club plan/do? The treasurer planned the car wash.
8. What did your mother rearrange/do? My mother rearranged the living room.
9. What did Andrew borrow/do? Andrew borrowed my Walkman.
10. What did the lawyer steal/do? The lawyer stole government documents.
11. What did the swimmer win/do? The swimmer won the gold medal.
12. What did Professor Green find/do? Professor Green found some Mayan ruins.
13. What did the governor revise/do? The governor revised the crime bill.
14. What did the drummer play/do? The drummer played the vibraphone.
15. What did the clown juggle/do? The clown juggled bowling balls.
16. What did the librarian repair/do? The librarian repaired the old book.
17. What did Fernando sing/do? Fernando sang *Stardust*.
18. What did Simone study/do? Simone studied European history.
19. Who did the surgeon phone/What did the surgeon do? The surgeon phoned the police.
20. Who did Laura interview/What did Laura do? Laura interviewed the prosecutor.
21. Who did Ms. Jones fire/What did Ms. Jones do? Ms. Jones fired the temp worker.
22. Who did Renae elbow/What did Renae do? Renae elbowed the senator.
23. Who did the teenagers frighten/What did the teenagers do? The teenagers frightened the old lady.
24. Who did Adam serenade/what did Adam do? Adam serenaded Beatrice.

C. Fillers
1. Who's dating Mike? Cassandra's dating Mike.
2. Who left the party early? Josh left the party early.
3. Who brought the wine? Mr. McCarthy brought the wine.
4. Who thinks David cheated on Sara? EVERYBODY thinks David cheated on Sara.
5. Who owns that junk-heap of a car? Bill owns that car.
6. Who decided we should use this book? Professor DiCarlo made that decision.
7. Who's responsible for the pamphlets? Rachel's responsible for them.
8. Who knows where the schedule is? Sage knows where it is.
9. Where did Oliver go to college? Oliver went to Michigan State.
10. Where did you get that great shirt? I got this at J. Rich.
11. Where did Pete wander off to? Pete went out to the garage.
12. Where is the bookstore? The bookstore is on the corner of Elm and Broadway.

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