

Making Sense of the Sense Unit Condition

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1. Introduction

Traditionally, it has been assumed that listener preferences for intonational boundary placement fall under the domain of linguistic competence. Under this view, native speakers of a language possess specific linguistic knowledge that specifies permissible intonational phrasings for a given utterance. Although, a number of theories of this type have been proposed (Nespor & Vogel, 1986; Hirst, 1993), Selkirk's (1984) may be the most successful to date. She proposes that the distribution of intonational phrase boundaries can be accounted for by a semantic constraint called the Sense Unit Condition (SUC):

(1) The Sense Unit Condition of Intonational Phrasing: The immediate constituents of an intonational phrase must together form a sense unit. Two constituents C_i , C_j form a sense unit if either (a) or (b) are true of the semantic interpretation of the sentence:

- a. C_i modifies C_j (a head)
- b. C_i is an argument of C_j (a head)

The SUC makes the following predictions for the sentences in (2):

- (2) a. John gave the book // to Mary.
- b. * John gave // the book to Mary.
- c. John gave // the book // to Mary

According to the SUC, (2a) is acceptable because both intonational phrases in the utterance form sense units. In (2b), the SUC is violated because the intonational phrase *the book to Mary* does not form a sense unit. *The book* and *to Mary* do not participate in a head-argument or head-modifier relationship. If an additional intonational boundary is added after *book*, as in (2c), the SUC predicts that the sentence should become acceptable because all three resulting intonational phrases form sense units.

An alternative account of the peculiarity of (2b) is provided by a theory grounded in processes involved with understanding and producing language. In particular, the Anti-Attachment Hypothesis (AAH; Watson & Gibson, 2003) in (3) provides an explanation of the judgments in (2):

(3) Anti-Attachment Hypothesis (AAH):

Listeners prefer not to attach an incoming word to a lexical head that is immediately followed by an intonational phrase boundary. As a result, the presence of a boundary at a local attachment site increases processing difficulty, and the presence of a boundary after a word that has no subsequent attachments decreases processing difficulty.

The AAH accounts for the judgments in (2) as follows. Sentence (2b) is less acceptable than the other two sentences because it includes a misleading cue: the intonational boundary between *gave* and *the book*. The presence of this boundary suggests to the listener that the NP *the book* does not integrate with the preceding verb *gave*, but this is incorrect, leading to an increase in processing difficulty. Sentence (2a) does not contain the misleading cue, and so this sentence sounds better. Sentence (2c) contains the misleading cue, but it also contains an additional helpful cue: the intonational boundary between *the book* and *to Mary*. This cue improves the acceptability of the sentence, because no additional words attach to the immediately preceding site *the book*.

Watson & Gibson (2003) propose that the AAH follows from listeners' implicit understanding of the relationship between intonational phrasing information and syntactic structure during the production of a sentence, and that they use this knowledge to infer aspects of syntactic structure when comprehending a sentence presented auditorily. Support for the AAH comes from people's preferences in interpreting ambiguity, and from complexity effects in unambiguous structures (see Watson & Gibson, 2003, for a full discussion). For example, the intonational boundaries placed in the globally ambiguous sentences below bias listeners towards one interpretation over the other:

(4) a. The cop saw // the spy with the telescope.

- b. The cop saw the spy // with the telescope.

In (4a), the boundary after the verb *saw* biases the listener towards an interpretation where the PP *with the telescope* modifies the noun *spy* (Schafer, 1997; Carlson, Frazier, & Clifton, 2001). According to the AAH, the intonational boundary acts as a cue not to attach incoming items to the verb *saw*, so the listener interprets the PP as a modifier of the direct object. Similarly, the AAH predicts that the intonational boundary in (4b) will bias the listener towards an interpretation where the PP modifies the verb because it signals non-attachment to the noun *spy*. This is consistent with the findings in the literature (Price et al., 1991; Pynte & Prieur, 1996; Schafer et al., 2001; Carlson, Frazier & Clifton, 2001).

2. Experiment 1

Experiment 1 tested the predictions of the SUC and the AAH, using the structures in (5) below. Boundaries were placed at positions (1) and (2) as indicated.

- (5)
- a. The detective showed the blurry picture of the diamond to the client
 - b. The detective showed the blurry picture (1) of the diamond to the client
 - c. The detective showed the blurry picture of the diamond (2) to the client
 - d. The detective showed the blurry picture (1) of the diamond (2) to the client

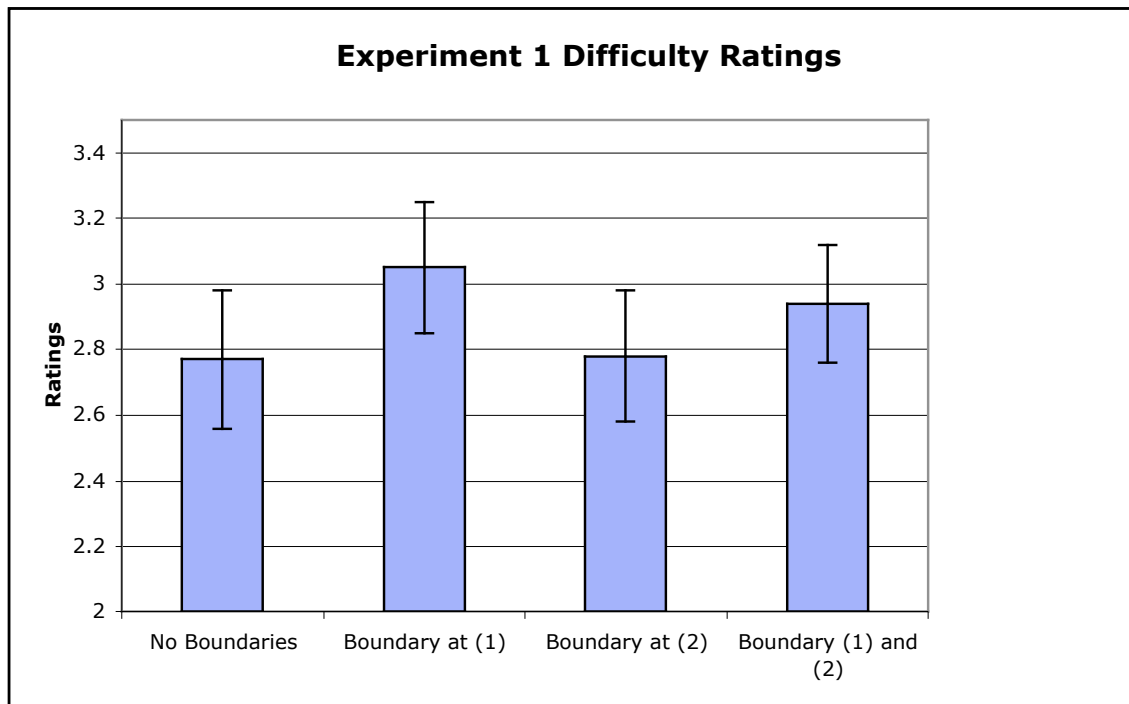
The PPs *of the diamond* and *to the client* do not form a sense unit. Thus the SUC predicts that (5b) – in which the two PPs are alone together in one intonational phrase – will be judged to be less acceptable than (5a), (5c), and (5d), because (5b) is the only structure that violates the SUC. The SUC makes no predictions about the other three sentence structures. Thus the SUC predicts an interaction between the presence of a boundary at (1) and the presence of a boundary at (2).

Like the SUC, the AAH also predicts that (5b) should be worse than the other three conditions, but unlike the SUC, the AAH predicts a main effect of boundary

placement at each of the two positions, and no interaction between the two effects. In particular, the AAH predicts that the boundary at the first position should make the sentences less acceptable, but the boundary at the second position should make the sentences more acceptable.

Forty-nine subjects participated in an auditory survey where they listened to 16 sentences with the same structure as sentence (5). They were asked to rate the difficulty of each sentence on a scale of 1 to 7 with 1 being very easy to understand and 7 being most difficult. The details of the experimental method are presented in the appendix. The resultant ratings are presented in Figure 1.

Figure 1. The mean difficulty ratings for the conditions in Experiment 1, on a scale from 1 to 7, where 1 indicates a sentence that is very easy to understand, and 7 indicates a sentence that is very difficult to understand.



As predicted by the both the SUC and the AAH, (5b) was numerically the least acceptable condition of the four. But the overall pattern of data was slightly better predicted by the AAH than the SUC. First, there was an overall effect of the boundary at position (1) that was marginal by subjects ($F_1(1,34) = 3.46, p = .07$) and significant by items ($F_2(1, 15) = 12.23, p < .01$). There was no effect of a boundary and no interaction between the two factors ($F_s < 1$).

Although the numerical pattern of data fits the predictions of the AAH, the boundary effect at position (2) did not reach significance. This effect may not have reached significance because of an independent factor: That very short intonational phrases sound somewhat peculiar. Placing a boundary before the sentence-final PP in (5) leaves the PP *to the client* as its own intonational phrase. People may have a preference for longer intonational phrases, or perhaps for more evenly spaced intonational boundaries through an utterance (Gee & Grosjean, 1983; Selkirk, 2000). In either case, the sentence-final PP in (5) is short, consisting of two function words and one content word, and it is short relative to the rest of the sentence.

The lack of an interaction was not predicted by the SUC, but this lack of an effect is not enough to rule out the SUC. As a result of these issues, a second experiment was designed to distinguish the predictions of the SUC from the AAH.

3. Experiment 2

In Experiment 2, the structures in (6) were tested with intonational boundaries at positions (1) and (2).

(6) a. Baseline

The CEO gave a portrait of the president to the manager on Wednesday.

b. Boundary after attachment site

The CEO gave a portrait (1) of the president to the manager on Wednesday.

c. Boundary after non-attachment site

The CEO gave a portrait of the president (2) to the manager on Wednesday.

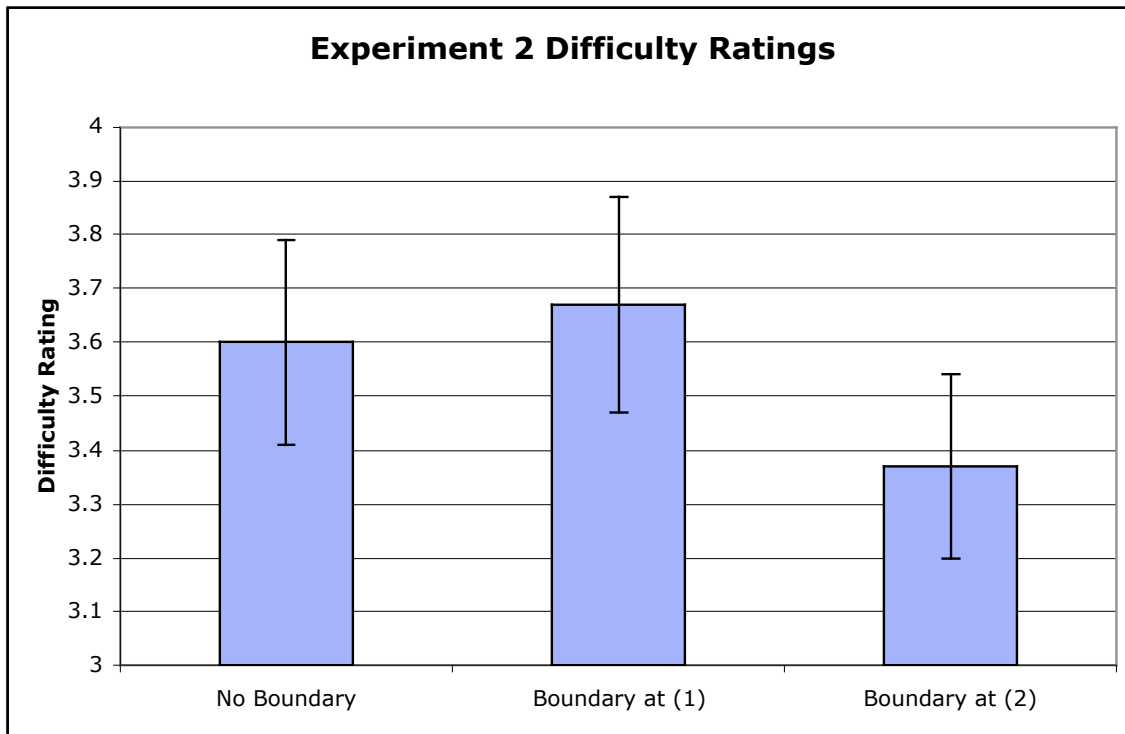
The SUC predicts that both (6b) and (6c) should be more difficult than (6a) because both of these structures violate the sense unit condition. The strings *of the president to the manager on Wednesday* and *to the manager on Wednesday* do not consist of constituents that engage in head dependency relationships with each other.

Like the SUC, the AAH predicts that (6b) should be more difficult than (6a) because an intonational boundary separates a local attachment between *portrait* and *of the president*. In contrast to the SUC, however, the AAH predicts that (6c) should be more acceptable than (6a) because the boundary between *president* and *to the manager* correctly signals a non-local attachment of the PP *to the manager*.

The design of Experiment 2 therefore differs from that of Experiment 1 because the SUC and AAH make opposing predictions in Experiment 2, in condition (6c). A further difference between the designs of the two experiments is that the material following the non-local attachment site boundary is longer in Experiment 2, consisting of two PPs (*to the manager* and *on Wednesday*) as opposed to a single PP in Experiment 1 (*to the client*). Hence, if people disprefer very short intonational phrases, then such a constraint should have less of an influence here than in Experiment 1.

We tested these predictions in an auditory survey similar to the survey conducted in Experiment 1. Forty-nine new participants rated 15 items with the structure in (6) in a survey similar to the one in Experiment 1. The results are presented in Figure 2.

Figure 2. The mean difficulty ratings for the conditions in Experiment 2, on a scale from 1 to 7, where 1 indicates a sentence that is very easy to understand, and 7 indicates a sentence that is very difficult to understand.



The condition containing a boundary at (2) was rated as less difficult than the condition with no boundary. This difference was significant in the participants analysis ($F_1(1,48) = 4.79, p < .05$) and marginally significant in the items analysis ($F_2(1,14) = 3.05, p = .10$). Although the condition with a boundary at position (1) was numerically less acceptable than the no-boundary condition, this difference was not statistically significant ($F_s < 1$).

4. Discussion

The pattern of data observed in Experiment 2 supports the anti-attachment hypothesis over the sense unit condition. Contrary to the prediction of the SUC, inserting a boundary at position (2) in the sentence structures in (6) made the sentences more acceptable, not less acceptable. This pattern of data was predicted by the AAH.

In comparing the results of the two experiments, it is interesting that the addition of a PP at the end of the materials in Experiment 1 resulted in a significant boundary effect at position (2) in Experiment 2. This effect was numerical, but not significant in Experiment 1. The shift in results provides suggestive support for the hypothesis that people disprefer sentences with very short intonational phrases, as in the materials in Experiment 1.

One puzzle remains in interpreting the results of the two experiments relative to the AAH. The addition of the PP at the end of the sentences in Experiment 2 also seems to have had the effect of reducing the boundary effect size at position (1), between the direct object and its argument. This effect was significant in Experiment 1, but only numerical in Experiment 2. It is possible that the numerical reduction in the effect size across the two experiments at this position may have been caused by a preference to have an intonational boundary in longer sentences. The sentences in Experiment 2 were longer than those in Experiment 1 (because of the inclusion of an extra PP). The additional sentence length may have introduced a greater preference to have a boundary somewhere in the materials in Experiment 2, thus counteracting the predictions of the AAH (and the SUC).

Although the details of all the constraints that affect intonational boundary placement in English are still wide open, overall the results provide strong evidence for a performance-based theory – the anti-attachment hypothesis – over a competence-based theory – the sense unit condition.

Appendix: Experimental details

Experiment 1 was a 2x2 design, varying the presence of an intonational boundary at the two locations indicated in (5). The sixteen experimental sentences were randomly presented with 51 unrelated sentences, so that participants would not be able to determine the nature of the experiment. The stimuli were presented in four counterbalanced lists in a Latin Square design such that each participant only saw one condition for each item. A yes/no question was presented after each sentence to ensure the subjects understood the sentences. Only ratings from trials with correctly answered questions were analyzed.

In Experiment 2, the fifteen experimental items were randomly presented with 30 unrelated sentences, as well as 30 sentences that were part of an unrelated experiment. The stimuli were presented in three counterbalanced lists.

The stimuli in each experiment were created through digital editing. Each condition was produced and recorded independently. For each item, a control sentence was produced that contained no intonational boundaries. In order to control the prosody among the sentences, the sections of each condition containing the manipulated intonational boundary were spliced into the control condition. The section included the pre-boundary word, the intonational boundary, and the post-boundary word. This was done in every condition, including the condition with no prosodic boundaries, to ensure that any differences in difficulty would not be attributable to irrelevant differences in prosody between the conditions or in the splicing itself.

The conditions with intonational boundaries were produced such that the final segment of the intonational phrase was lengthened and was followed by a perceptually salient boundary. All of the sentences were produced with a declarative intonation. An H* pitch accent occurred on the pre-boundary word in all conditions, and the intonational phrase ended in a L% boundary tone. The pause between intonational phrases was approximately 200ms.

Experiment 1 Items

1. The detective showed the blurry picture (1) of the diamond (2) to the client.
2. The spy sent the secret message (1) about the blueprint (2) to the general.
3. The writer loaned the interesting script (1) for the screenplay (2) to the producer.
4. The cashier directed the exasperated mother (1) of the child (2) to the manager.
5. The agent mailed the critical review (1) of the story (2) to the manager.
6. The manager distributed the thick manual (1) for the software (2) to the employees.
7. The publisher mentioned the war poem (1) about the hero (2) to the editor.
8. The senator left the ornate portrait (1) of the mansion (2) to a foundation.
9. The surgeon prescribed the small bottle (1) of the medication (2) to the athlete.
10. The housewife slipped the small vial (1) of the poison (2) to the guest.
11. The tutor explained the difficult chapter (1) of the book (2) to the student.

12. The supervisor distributed the short memo (1) about the hardware (2) to the employees.
13. The firefighter mentioned the possible danger (1) of the explosion (2) to the chief.
14. The musician provided the interactive webpage (1) about the music (2) to the fans.
15. The salesman gave the informative presentation (1) about the product (2) to the customers.
16. the mathematician described the convoluted logic (1) of the puzzle (2) to the academics.

Experiment 2 Items

1. The CEO of the company gave a portrait (1) of the president (2) to the manager on Wednesday.
2. The courier for the company delivered a copy (1) of the documents (2) to the secretary after lunch.
3. The intern at the office gave a fax (1) of the contracts (2) to the lawyer at noon.
4. The millionaire at the party donated a painting (1) of the skyline (2) to the museum on New Year's Day.
5. The manager of the store offered a description (1) of the suspect (2) to the police after the robbery.
6. The commander of the squad provided a briefing (1) of the mission (2) to the troops at daybreak.
7. The architect for the project presented a model (1) of the building (2) to the committee on Monday.
8. The emperor of the island awarded a portion (1) of the land (2) to the general after the invasion.
9. The professor of the class recommended a revision (1) of the rough drafts (2) to the students on Friday.
10. The representative of the company provided a demonstration (1) of the software (2) to the clients during the meeting.
11. The journalist at the battle contributed a story (1) about the war (2) to the magazine in April.

12. The author of the book dedicated the biography (1) of the actress (2) to his wife in the acknowledgements.
13. The director of the play suggested the omission (1) of the scene (2) to the producer before the rehearsal.
14. The parents of the child mailed a picture (1) of the boy (2) to an agent on Friday.
15. The expert on the region brought a summary (1) of the situation (2) to the senator after the bombing.

Works Cited

- Carlson, K. Clifton, C., & Frazier, L. (2001). Prosodic boundaries in adjunct attachment. *Journal of Memory and Language*, 45, 58-81.
- Gee, J.P., & Grosjean, F. (1983). Performance structures. A psycholinguistic and linguistic appraisal. *Cognitive Psychology* 15, 411-458.
- Hirst, Daniel (1993) Peak, boundary and cohesion characteristics of prosodic grouping., *Linguistic Inquiry*, 24, 781-788
- Nespor, M. & Vogel, I. (1986). *Prosodic Phonology*. Dordrecht: Foris Publications.
- Price, P.J., Ostendorf, M., Shattuck-Hufnagel, S., & Fong, C. (1991). The use of prosody in syntactic disambiguation. *JASA* 90, 2956-2970.
- Pynte, J. & Prieur, B. (1996). Prosodic Breaks and Attachment Decisions in Sentence Parsing. *Language and Cognitive Processes*, 11, 165-191.
- Schafer, A.J. (1997). Prosodic Parsing: The Role of Prosody in Sentence Comprehension. University of Massachusetts Doctoral Dissertation., Amherst: GLSA.
- Schafer, A.J., Speer, S.R., Warren, P., & White, S.D. (2001). Prosodic influences on the production and comprehension of syntactic ambiguity in a game-based conversation task. Paper presented at the Fourteenth Annual CUNY Conference on Human Sentence Processing, Philadelphia, PA.
- Selkirk, E. (1984) *The Relation Between Sound and Structure*. Cambridge: MIT Press.
- Selkirk, E. (2000). The interactions of constraints on prosodic phrasing. In *Prosody: Theory and Experiment*, ed. M. Horne, Dordrecht: Kluwer Academic.

Watson, D. & Gibson E. (2003). Intonational phrasing and constituency in language production and comprehension. Manuscript submitted for publication