Eye-Tracking Evidence for the Active Role of Intonational Boundaries in Parsing Decisions

Eun-Kyung Lee, Yoonsook Mo and Duane G. Watson
University of Illinois at Urbana-Champaign
eklee1@uiuc.edu

Abstract

This study investigates how prosodic phrase boundaries are interpreted by listeners in on-line comprehension. We examined whether boundaries act as a signal to syntax, or whether their effect is a by-product of the packaging of syntactic constituents. The eye movement data suggest that local intonational boundaries are actively processed by listeners and are interpreted as signaling upcoming syntactic structure.

Target Construction

(1) The man met the father (a) of the girls (b) who is riding a bicycle.

Previous Studies

□ How do prosodic phrase boundaries influence attachment preferences?

1. Prosodic groupings resulting from prosodic phrase boundaries affect parsing decisions (Frazier & Clifton, 1998; Schafer, 1997)

   1) A boundary at (a) in (1) will induce higher rates of low attachment because *girls* is in the same intonational phrase as the relative clause
   2) A boundary at (b) will have no effect

2. Prosodic phrase boundaries themselves affect parsing decisions (Carlson et al., 2001; Marcus & Hindle, 1990; Watson & Gibson, 2005)

   1) A boundary at (a) signals low attachment.
   2) A boundary at (b) signals high attachment

These theories have only been tested in off-line studies.

Present Study

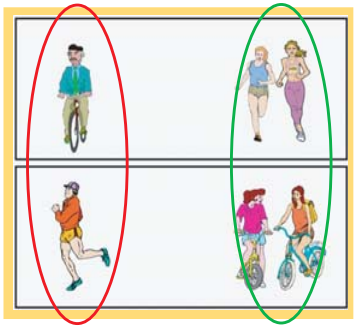
□ **Research Question:**
How are prosodic phrase boundaries processed by listeners on-line?

We test the following two hypotheses:

1. Passive Boundary Hypothesis:
Prosodic phrase boundaries passively affect parsing decisions as a consequence of prosodic packaging

2. Active Boundary Hypothesis:
Prosodic phrase boundaries themselves are informative and actively used by listeners as cues to upcoming syntactic structure.

Example Visual Display



□ Auditory instructions:

(2) Click on the father (a) of the girls (b) who is/are riding a bicycle.

□ Each display included two Target pictures that correspond to the high noun phrase in an auditory instruction (e.g. fathers) and two Relative pictures that correspond to the low noun phrase (e.g. girls)

□ Participants were told that boxes around a pair of pictures indicated a family relationship.

Conditions & Predictions

□ 4 Boundary conditions:

(3) a. No: Click on the father of the girls who is riding a bicycle.
b. NP1: Click on the father // of the girls who is riding a bicycle.
c. NP2: Click on the father of the girls // who is riding a bicycle.
d. Both: Click on the father // of the girls // who is riding a bicycle.

□ **Predictions**

▪ A boundary at position (a):
1. Passive Boundary Hypothesis: greater fixations away from the Target pictures after the relative clause is encountered
2. Active Boundary Hypothesis: greater fixations away from the Target pictures as soon as the boundary is encountered.

▪ A boundary at positions (b):
1. Passive Boundary Hypothesis: no effect of boundary
2. Active Boundary Hypothesis: greater fixations away from the Relative pictures as soon as the boundary is encountered.

Methods & Acoustic Analysis

□ Methods
- 32 participants from UIUC
- Eye fixations were recorded
- 24 critical items and 46 distractor items

□ Acoustic Analysis
- Each boundary equivalent with the perceptual equivalent of a '4' in the ToBI coding scheme
- When boundaries are present, longer duration of preceding nouns (plus following pauses) (N1: F(1,23)=2884.38, p<.001; N2: F(1,23)=3605.54, p<.001) and greater pitch reset (after N1: F(1,23)=289.17, p<.001; after N2: F(1, 23)=8.801, p<.01)

Results

□ The data from 8 subjects who were biased consistently towards either LA or HA were excluded from the analysis

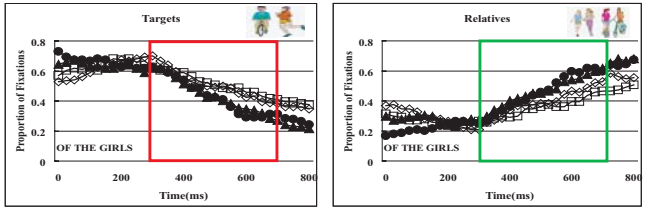
□ Percentages of error selection in LA and HA trials by condition

	No	NP1	NP2	Both
LA	4.17%	2.78%	6.94%	4.17%
HA	34.67%	40.00%	24.00%	25.33%

- No main effect of condition (LA: F1(3, 21)=.43, p>.1, F2(3,21)=.57, p>.1; HA: F1(3,21)=2.05, p>.1, F2(3,21)=1.66, p>.1)

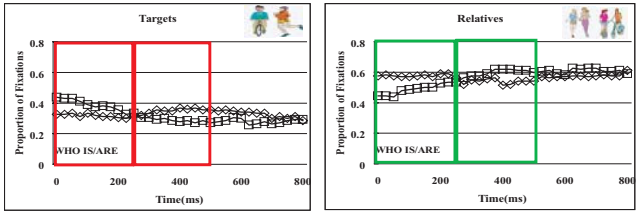
□ Eye Fixation Data
- All critical sentences synchronized at the beginning of each of the two words immediately following the intonational boundaries: 1) *of* and 2) *who*

After the onset of *of* (y-axis : Proportion of Fixations) □ No ●Both ▲NP1 ◊ NP2



- Main effect of boundary over the time window 300-700 ms from the onset of *of* (Targets: F1(1,23)=8.2, p<.01, F2(1,23)=4.48, p<.05; Relatives: F1(1,23)=8.92, p<.01, F2(1,23)=6.3, p<.05):
  - Fixation proportions to the Target pictures: NP1 & Both < No & NP2

After the onset of *who* (y-axis : Proportion of Fixations) □ No ◊ NP2



- Marginally significant interaction between region(0-250ms vs. 250-500ms) and boundary (Targets: F1(1,23)=3.66, p<.07, F2(1,23)=1.77, p>.1; Relatives: F1(1,23)=3.15, p<.09, F2(1,23)=4.36, p<.05) → A weak effect of boundary after NP2

Conclusion

□The results support the Active Boundary Hyothesis: intonational boundaries provide sufficient information to drive anticipatory fixations, and are actively perceived by listeners as cues to upcoming syntactic structure.