Processing ambiguity: the role of prosodic structure

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1. Introduction

A central problem in the study of language is how the speech signal is segmented into word and phrase-sized units.

A way to address this issue is to examine the processing of utterances with temporary ambiguities.

Prosody is known to constrain both **lexical access** and **syntactic analysis** in ambiguous sentences. Salverda et al. (2003), Chistophe et al. (2004), Millotte et al. (2007, 2008), Li & Wang (2009)


- Intonational Phrase (IP) > general agreement on the role it plays on disambiguation (although differences are reported between expert and naïve speakers)
- The role of lower phrase boundaries and of the PW is more controversial (divergent results across studies/languages studied)
1. Introduction

• We address the role of prosodic structure in the processing of both lexical and syntactic ambiguities in European Portuguese (hereafter EP)

• Our goal is to examine the effects of the full range of prosodic constituent boundaries reported for EP in previous literature and establish which boundary(ies) may constrain lexical and syntactic disambiguation.

• Prosodic structure in EP:  
  - IP: Intonational Phrase
  - PhP: Phonological Phrase
  - PWG: Prosodic Word Group
  - PW: Prosodic Word
2. Prosodic structure in European Portuguese (EP)

- **Prosodic Word** (Vigário 2003)
  - Word stress (& related processes)
  - Edge-phenomena (phonotactic constraints, many segmental processes)
  - Clipping, deletion under identity

- **Prosodic Word Group** (Vigário 2008, 2009)
  - Different level of stress (with specific effects on segmental processes)
  - Blockage of phonological processes of vowel deletion
  - Focus assignment

- **Phonological Phrase** (Frota 2000)
  - Stress strengthening in SC
  - Rhythmic constraints on vowel sandhi

  - Many segmental processes
  - Domain for resyllabification
  - Final lengthening, pauses
  - Left-edge strengthening
  - Domain for pitch accent distribution
  - Length affects IP-phrasing
1. Introduction

- Given the results from previous work on other languages and the properties of the different prosodic domain types just described, we predict:

1. Listeners will be able to exploit PW /PWG boundaries (despite Li & Wang 2009 results for Chinese)
2. Difficulty to detect the PhP as different from the PW (despite Christophe et al 2004, Milotte et al 2007, 2008 results for French)
3. Clear disambiguating role of the IP
4. If the role of prosodic structure is grammar-based and not merely input-based, we expect a consistent effect of prosodic conditions across subjects and only a weak speaker effect.
2. Methods: Completion task  (adaptation from Millotte et al. 2007)

Materials

Pairs of sentences with temporary ambiguity were created consisting of homophonous sequences in the target stretch.

The homophonous sequences have the exact same prosodic structure, to the exception of the boundary type contrast tested.

The pairs of sentences are matched for number of syllables.

Number of PWs and number of PhPs were also controlled (differently from Millotte et al.).

Syllable onsets after the target stretch were also matched.

(Sem.pre que re.ú.ne) **PhP** (a co.mi.ssão) (sa.i.mos) (mais ce.do) (do tra.ba.lho)

‘Everytime the committe meets we get out earlier from work’

(Sem.pre que re.ú.ne) **IP** (a co.mi.ssão) (sus.pen.de) (os tra.ba.lhos)(na se.de)

‘Everytime it meets, the committee cancels work assignments in the head office’
2. Methods: Completion task (adaptation from Millotte et al. 2007)

Materials

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(Sem.pre que re.ú.ne) **PhP** (a co.mi.ssão) (sa.í.mos) (mais ce.do) (do tra.ba.lho)
(Sem.pre que re.ú.ne) **IP** (a co.mi.ssão) (sus.pen.de) (os tra.ba.lhos) (na se.de)

Frequency of the relevant words was checked (corpus 133,000 words)
2. Methods: Completion task

Production

2 native speakers of standard EP (expert: aware of the ambiguity/naïve: not aware) were recorded individually.

Each member of a pair of ambiguous sentences appeared in a different block, interspersed with fillers (96 test items+24 fillers).

Before recording, participants were asked to read the sentences silently and produce them in a natural way.

Each sentence was presented on a monitor and recorded in a sound proof room (a digital recorder was used, 44.100Hz).

Participants had a break between blocks.

Prosodic conditions: withinPW/betweenPW; withinPWG/betweenPW; withinPWG/PhP; PW/PhP; PW/IP; PhP/IP
2. Methods: Completion task

Completion

24 subjects (native speakers of standard EP, university students) did the completion task

Members of ambiguous pairs were assigned to different blocks; 12 subjects listened to block A; another 12 to block B

48 test items plus 8 fillers per block

Test items were cut right after the end of the ambiguous word (at a zero-crossing of the amplitude signal)

Subjects were asked to write the listened sentence and complete it as they saw fit in a response sheet. They could listen to the item as many times as they wished.

E.g. Sempre que reúne a comissão > PhP: **SubjectNP** / IP: **Verb**
2. Methods: Completion task

Gosto da [pintadela]PW que deste ao armário
  painting
Gosto da [pinta]PW [dela]PW neste filme espanhol
  the way she looks
O miúdo [foi [mal]PW [criado]PW]PhP pelos avós
  badly raised
O miúdo foi [[mal]PW[criado]]PWG com os avós
  rude
O rolo de [fita]PW[cola]PWG ficou na secretária dela
  tape
O rolo [de [fita]PW [cola]PW]PhP figuras pretas na parede
  stripe sticks
Estando ausente ]PhP o João (John is away), ficou um lugar....
Estando ausente ]IP o João (Being away John calls) fazia telefonemas
3. Results: expert speaker

Boundary type effect

- Post hoc comparisons between groups (Tukey HSD)
  - withinPW/betweenPW: NS
  - withinPWG/betweenPW: NS
  - withinPWG/betweenPhP: \( p < .001 \)
  - betweenPW/betweenPhP: \( p = .01 \) (borderline)
  - betweenPW/betweenIP: \( p < .001 \)
  - betweenPhP/betweenIP: \( p = .001 \)

ANOVA: prosodic condition, \( F = 19.2 \) \( p < .001 \)
3. Results: naïve speaker

Boundary type effect

- Post hoc comparisons between groups (Tukey HSD)
  - withinPW/betweenPW: NS
  - withinPWG/betweenPW: NS
  - withinPWG/betweenPhP: \( p = .003 \)
  - betweenPW/betweenPhP: NS
  - betweenPW/betweenIP \( p < .0001 \)
  - betweenPhP/betweenIP \( p < .0001 \)

ANOVA: prosodic condition, \( F = 13.7 \) \( p < .001 \)
3. Results: expert speaker

WithinPW/betweenPW
Strong item effect and a bias towards withinPW

WithinPWG/betweenPW
Strong item effect and a bias towards the compound W

ANOVA: item, $F=13.1$, $p<.001$

ANOVA: item, $F=12.1$, $p<.001$
3. Results: naïve speaker

**WithinPW/betweenPW**

Strong item effect and a bias towards withinPW

**WithinPWG/betweenPW**

Strong item effect and a bias towards the compound W

**ANOVA**: item, F=30.1, p<.001

**ANOVA**: item, F=4.7, p<.001
3. Results: within PWG/between PhP

Expert speaker
Significant **boundary** effect

Naïve speaker
Significant **boundary** effect

Item effect: $F=2.6$, $p=.006$

12,13:PhP

Item effect, $F=6.1$, $p<.001$

12,13:PhP (more bias > PWG)
3. Results: between PW/between PhP

Expert speaker
Weak **boundary** effect

Naïve speaker
No **boundary** effect

Item effect: F=9.7, p<.001
2,7:PW

Item effect, F=23.5, p<.001
2,7:PW (2,7,6,8 vs. 4,5,9,10)

Similar pattern (with more extreme values)
3. Results: between PW/between IP

Expert speaker
Significant **boundary** effect

Naïve speaker
Significant **boundary** effect

NO item effect: F=1.3, p=.26
Longer phrases favour IP
(nº of syllables, not PWs)

NO item effect, F=1.5, p=.12
Longer phrases favour IP
(nº of syllables, not PWs)
Tendency for a length effect: =>6 syllables (both speakers)

Between PW/between IP

Expert speaker
Significant boundary effect

Naïve speaker
Significant boundary effect

NO item effect: $F=1.3$, $p=.26$
Longer phrases favour IP
(no of syllables, not PWs)

NO item effect, $F=1.5$, $p=.12$
Longer phrases favour IP
(no of syllables, not PWs)
3. Results: between PhP/between IP

**Expert speaker**

Significant **boundary** effect

**Naïve speaker**

Significant **boundary** effect

Strong **length** effect (esp. for nº of syllables): $F=40.7$, $p<.001$

1,2,5,6,8 vs. 3,4,7

Strong **length** effect (stronger for nº of syllables: $F=20.5$, $p<.001$; nº of words: $F=10.2$, $p=.002$)
Supports the length threshold for division into IPs in SVO utts: >5

Elordieta et al. 2005

3. Results: between PhP/between IP

Expert speaker

Significant **boundary** effect

Naïve speaker

Significant **boundary** effect

Strong **length** effect (esp. for nº of syllables): F=40.7, p<.001

1, 2, 5, 6, 8 vs. 3, 4, 7

Strong **length** effect (stronger for nº of syllables: F=20.5, p<.001; nº of words: F=10.2, p=.002)
3. Results: both speakers

No **subject** effect

Results by prosodic condition with subject as a factor

Cond.1: $F = .22, p = .99$
Cond.2: $F = .72, p = .72$
Cond.3a: $F = 1.4, p = .18$
Cond.3b: $F = .47, p = .92$
Cond.4a: $F = 1.3, p = .24$
Cond.4b: $F = .36, p = .97$

No significant interaction between subject and prosodic condition
4. Summary

• **Boundary type effect**

1. **Significant** for withinPWG/betweenPhP
2. **Nearly significant** for betweenPW/betweenPhP (just for the expert sp.)
3. Contrasts at the word level and below **not significant** and with a strong **item effect**

Prosodic conditions at these levels show a bias towards withinPW or withinPWG (lower level is preferred)

4. The IP condition shows a strong **length effect** in nº of syllables

• **No subject effect**
• **No speaker effect** (the difference in the PW/PhP condition is NS - Tukey HSD)
• **Contrasts between non-adjacent p-levels** always significant (NB: withinPW/PhP, 2items)
5. Conclusion

1. Listeners are NOT be able to exploit PW /PWG boundaries (like in Li & Wang 2009 results for Chinese; contra predictions based on EP literature); bias towards whole words, except when a PhP-boundary intervenes; strong item effects not accounted for by word frequency; future research > explore larger frequency corpus, word size, syntactic structure frequency.

2. Difficulty to detect the PhP as different from the PW (despite Christophe et al 2004, Milotte et al 2007, 2008 results for French; in accord with predictions based on EP facts, arguing for language specificity); however, PhP is detected relative to the internal PWG boundary, suggesting a distinction PWG/PW.

3. The disambiguating role of the IP is confirmed, but subject to length conditions (nº syllables) that match previous findings based on production. This suggests that size is a restriction used to predict phrasing (Serra 2009, BP perception).

4. A consistent effect of prosodic conditions across subjects and speakers (expert/naïve), suggesting that the role of prosodic structure is grammar-based and not merely input-based.
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