When prosody is (not) needed or enough: an eye-tracking study of prosodic disambiguation in European Portuguese

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overview

introduction

* The processing of ambiguity in speech has been studied as a means to understand how prosodic cues may, or may not, impact speech processing, namely by constraining lexical access and syntactic processing.

* Numerous studies across languages have shown that prosody provides different types of cues, from word to phrasal levels (Friederici, 2002, Millotte et al. 2008; Diley & MacAulley, 2008; Cutler et al. Cole, 2015; for review).

* General support for the role of Intonational Phrase boundaries (IP).

  * More controversial effects of lower prosodic boundaries.

  * Different results for the effects of Phonological Phrase boundary (PhP) (e.g. French vs EP).

  * Word level boundaries less explored (as different from phrasal levels, and not focusing on particular phenomena, e.g. stress patterns, phonotactic cues and/or tones).

introduction

* Phrasal Level boundaries: how prosody guides speech chunking and interpretation of utterances.

* Relation between prosodic structure and syntactic category > Constituent Attachment.

"Hide $_1$ the rabbit $_2$ with a cloth"

* In English:
    * presence of high level boundary ($_2$) favors high attachment.
    * absence of high level boundary (= low level boundary) in ($_2$) or high boundary in ($_1$) favors low attachment (e.g. Watson & Gibson, 2005, Price et al., 1991).
    * However, 5 year olds pursued high attachment (Tueswell et al, 1999; Snedeker & Trueswell, 2004)

* Relation between prosodic structure and lexical access.

"Le chat$_3$ possessif" *(vs chapeau)*   *"Le chat $_4$ grimpait"* *(vs chagrin)*

* In French:
    * When compared to word level boundaries ($_3$), higher level boundary ($_4$) favors lexical access. (Christophe et al., 2004)

introduction

* **European Portuguese**

* Previous studies have shown that prosody guides the resolution of temporary ambiguity by adults.

* There is a clear effect of Intonational Phrase boundaries (IP) > minimum number of syllables required (Elordieta et al. 2005; Severino, 2011)
  * Offline task: only long IPs are interpreted as so (> 6 syllables)
  * Online task: long PhPs are interpreted as IP boundaries.

* A less robust effect of the Phonological Phrase (PhP), which is described as weakly marked in the language (Frota et al, 2010).

* For disambiguation at word boundary levels (PW, PWG), online perception studies shown to be more sensitive in detecting them. (Vigário, 2003; Severino, 2011)

* Contrasts between non-adjacent boundary levels favour disambiguity > bigger prosodic distance.

introduction

* **European Portuguese**

* Different tasks presented different results:
  * offline tasks > higher sensitivity to boundaries in phrase-level disambiguation
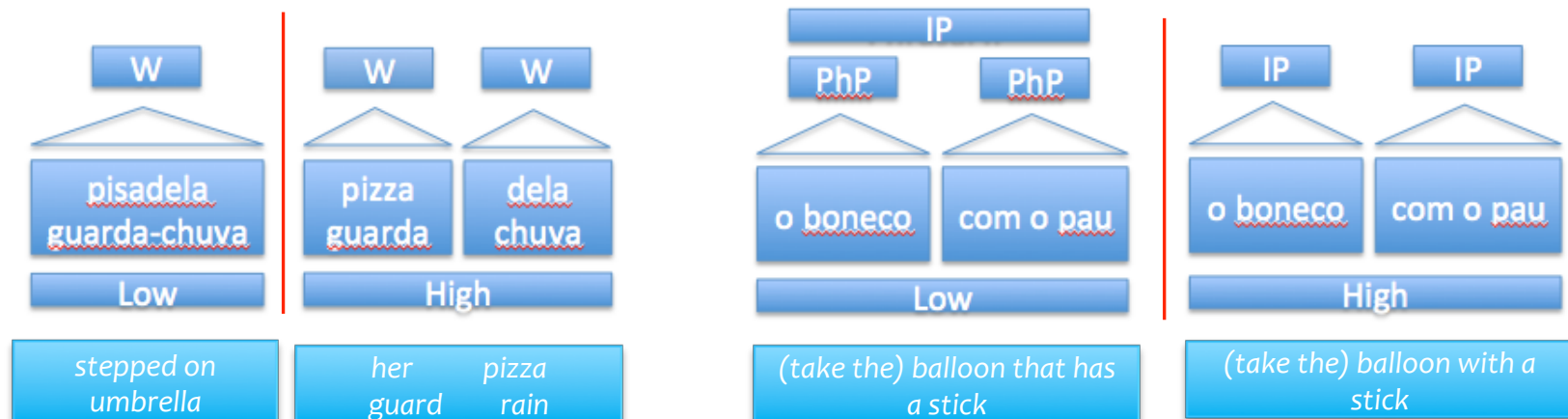 * online tasks > higher sensitivity to prosodic boundaries in word-level disambiguation

  Also reported in other studies:

* Relative clause attachment (Maia et al., 2007)
  * preference for high attachment in Portuguese with an offline task, showing more errors when material forced low attachment.
  * an initial advantage for low attachment in online tasks, with longer reaction times when materials forced high attachment.
  * Prosody not fully controlled.

* Different results with different task across and within languages (Watson et al, 2012)

Further studies of the role of prosodic boundaries in European Portuguese, in adult and children

main goals

* As part of a project on the role of prosody in disambiguation in language development, 20 adults were tested with sentences with global ambiguity, following Brandt-Kobele & Hoehle, 2010 and Snedeker & Yuan, 2008, to:

  * better understand the role of prosody in lexical and syntactic processing, using utterances with lexical and phrasal ambiguities

  * examine the effects of word level prosodic cues and phrase level prosodic cues

W	W	W
pisadela guarda-chuva	pizza guarda	dela chuva
Low	High	

stepped on umbrella	her pizza guard rain

IP	
PhP	PhP
o boneco	com o pau
Low	

IP	IP
o boneco	com o pau
High	

(take the) balloon that has a stick	(take the) balloon with a stick

Prosodic contrast: Word Level Boundaries (low boundary vs high boundary)

Phrasal Level Boundaries (PhP vs IP)

methods: materials

* Sets of ambiguous sentences were created for the 2 experimental contrasts, which only differed in prosodic boundary type :

* Word Level contrast

  * *Low: O Tito levou uma pisadela$_{no\ boundary}$ (Tito was stepped on)*

  * *High: O Tito levou uma pizza$_{pw}$ dela (Tito took her pizza)*

* Phrasal Level contrast

  * *Low: O Tito tira o balão$_{php}$ com o pau. (Tito takes the balloon that has a stick)*

  * *Lowp: O Tito tira $_{pause}$ o balão$_{php}$ com o pau.*

  * *High: O Tito tira o balão, $_{ip}$ com o pau. (Tito takes the balloon using a stick)*

* control condition: unambiguous sentence for each set

* O Tito anda de baloiço no recreio (Tito played on a swing in the playground)

method: procedure

* A trained female speaker produced the utterances
* Acoustic analysis and intonational analysis were performed

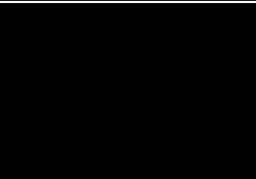|	Tonal Events		Duration		
			Stressed Syllable	Post-stress Syllable	Pause
Low	___	H+L⁺ L%	0.185	0.182	-
High	H+L⁺	H+L⁺ L%	0.219	0.201	
Low	___	H+L⁺ L%	0.235	0.150	-
Lowp	___	H+L⁺ L%	0.205	0.165	0.187
High	H+L⁺L%	H+L⁺ L%	0.363	0.227	0.266
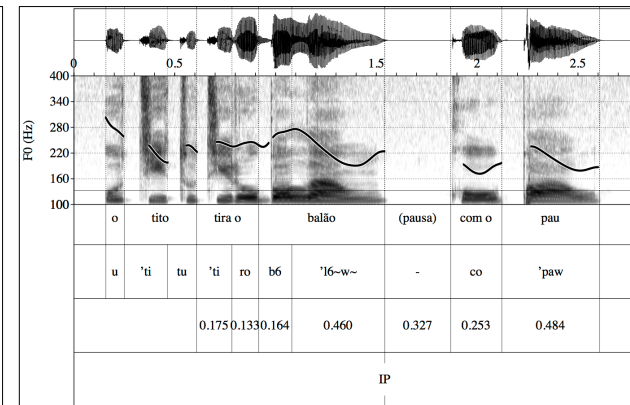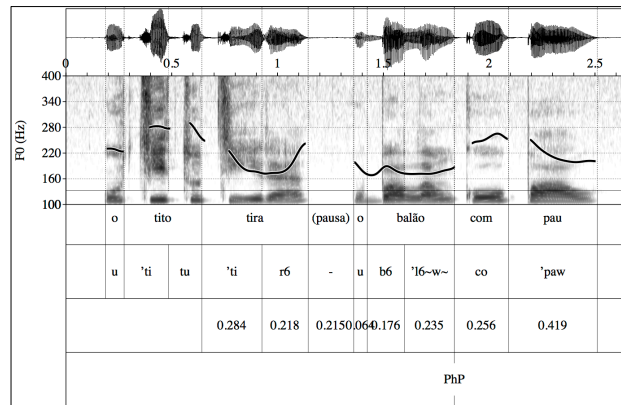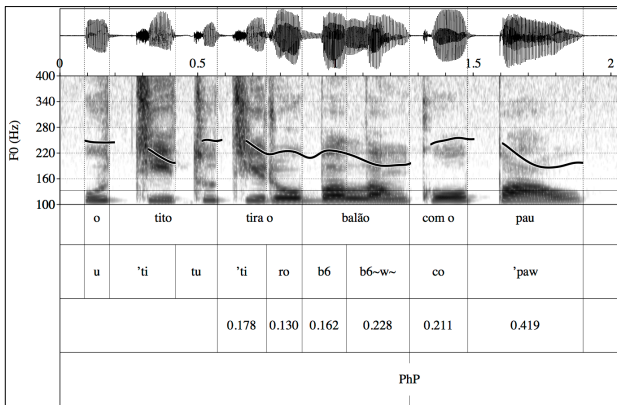
method: procedure

* For each sentence, a picture of the described situation was created. Pilot testing for image validation was performed.

* Pictures were paired and counterbalanced by side (L/R; R/L) within subjects.

* 2 experimental sets were built (Word level, Phrase Level), each of them with 2 blocks (version 1 and version 2). Subjects performed 1 block of each prosodic contrast and heard 1 sentence of each set of ambiguous utterances. Each subject was tested for all the boundaries.

* Total blocks: 2 word level+ 2 phrasal level

* Event trials: 9 target + 8 controls

method: procedure

* Task instructions were presented at the beginning of the experiment, followed by a training unambiguous set.

* Testing phase started with two control trials, followed by pseudo-randomized order of trial presentation.

* Each trial consisted of a gaze task, followed by a pointing task, where participants were asked to point to the picture matching the sentence only after instruction (*Aponta!*)

gaze	Baseline (3s) (image presentation)		*Olha!* (Look!)
	Sound Presentation (2s) (sound offset aligned with picture offset)		*O Tito levou uma pizza]pw dela.* (Tito took one of her pizzas.)
	Test (3s)		No sound
pointing	Pointing order		*Agora aponta!* (Now point!)
	Pointing (3s)		No sound

method: procedure

* Eye gaze was measured using SMI RED 500 Eye Tracker, with a 60hz tracking resolution, 5 points calibration, 70 cm screen distance.

method: data analysis - gaze
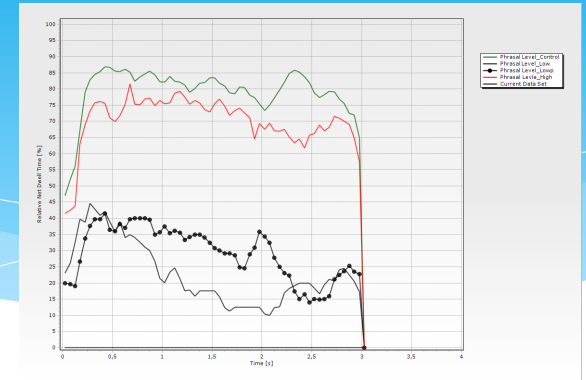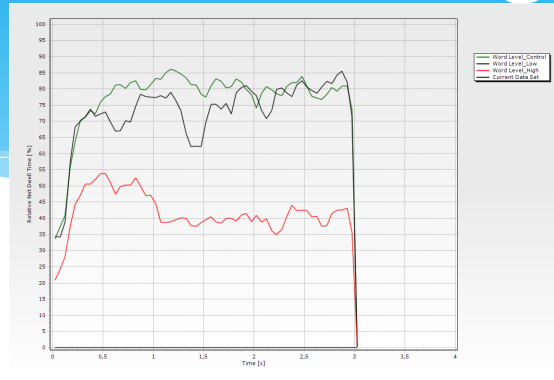
* Proportion of net dwell looking time at the target picture was used as the dependent variable. Only gaze task events were considered for gaze analysis.

* 2 AOI areas were defined on pictures (target/distractor)

* Proportion of Looks graphs were plotted to inspect visual behavior over test phase time course on boundary levels.

* Repeated Measures ANOVA

  * 2 within-subject factors: phase (Baseline vs Test), boundary level (Low, (Lowp), High, Control). 1 between-subject factor: experimental block (version 1 vs version 2)

  * When Mauchly's test indicated that the assumption of sphericity had been violated, degrees of freedom were corrected.

method: data analysis - pointing

* Pointing to target picture was used as dependent variable. Only pointing task events were analysed.

* Pointing direction was coded by researcher (online coding and offline coding check) through video.

* Repeated Measures ANOVA

  * 1 within-subject factor: boundary level (Low, (Lowp), High, Control). 1 between-subject factor: experimental block (version 1 vs version 2)

  * When Mauchly's test indicated that the assumption of sphericity had been violated, degrees of freedom were corrected.

gaze results: word level

Proportion looking at target picture
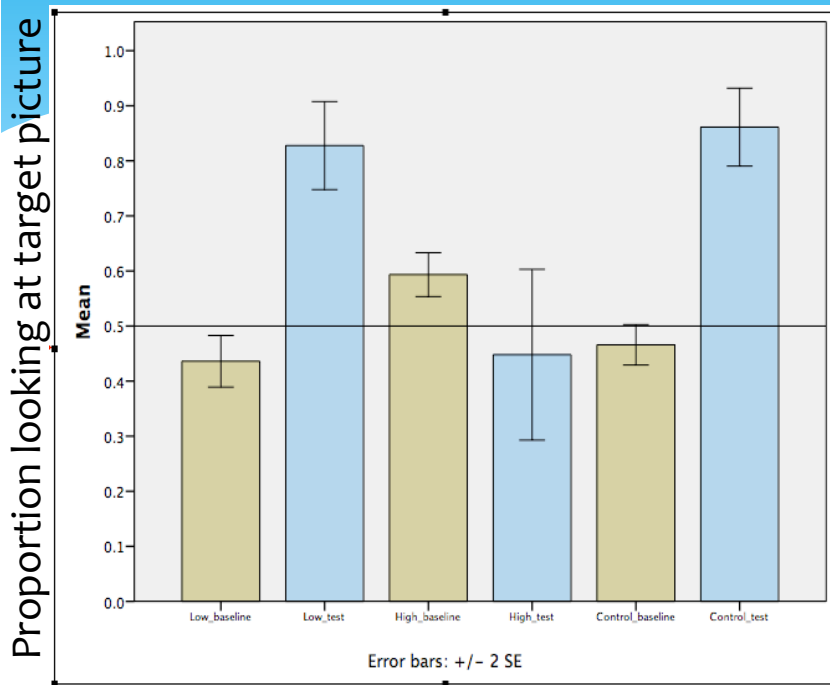
Adults were able to identify low word boundaries, but struggled when facing high level prosodic word boundary

* Significant main effects of Phase (F(1,18) = 50.65, p<.001) and Boundary Level (F(1.42, 25.48) = 5,35, p<.05)
* Significant interaction, Phase*Boundary Level (F(1.39, 25.01) = 31.64, p<.001)
* No significant effect of Experiment Block (F(1, 18) = 0,81 , p=.78)

pointing results: word level

Proportion looking at target picture
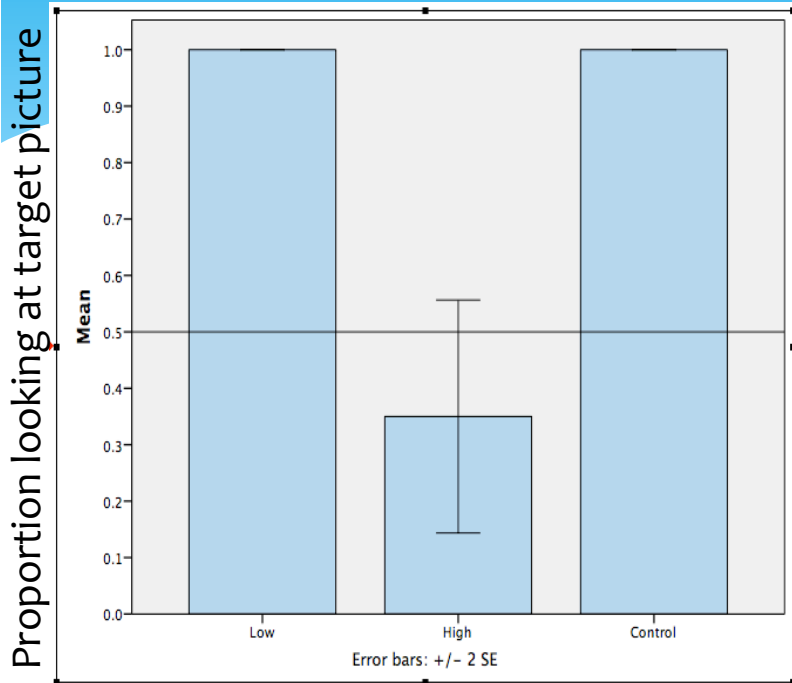
| pisadela pizza dela | → | pisadela (?) |

Pointing results confirm gaze data: Identification of low word boundaries, but not as clear results for high level prosodic word boundaries.
Bias for whole word interpretation.

* Significant main effect of Level (F(2, 36) = 42.25, p<.001)
* No significant main effect of Experiment Block (F(1,18) = 2.25, p=.15)
* No significant interaction, Level*Experiment version (F(2, 36) = 2.25, p=.12)

gaze results: phrasal level


Error bars: +/- 2 SE
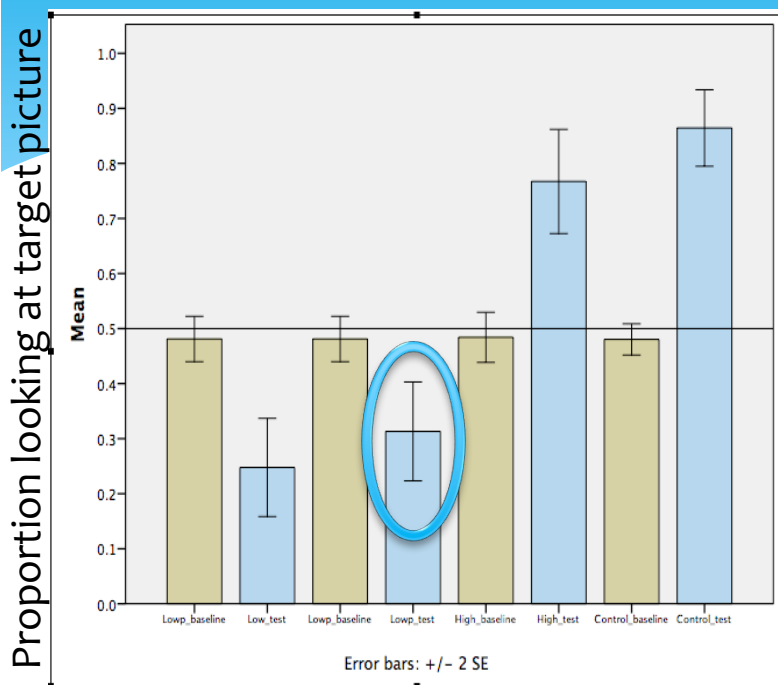
Regardless of boundary type, adults processed all stimuli as high attachment. Clear bias to interpret as IP, even when prosodic cues were expected to block it were present (Lowp)

* Significant main effects of Phase (F(1,18) = 6.74, p<.05) and Boundary Level (F(3, 54) = 42.63, p<.001)

* Significant interaction Phase*Level (F(2.13, 38.26) = 46.73, p<.001)

* No significant effect of Experiment Block(F(1, 18) = 1.03, p=.324)

pointing results: phrasal level

Always looking to the same picture (High Level picture)

Proportion looking at target picture

Error bars: +/- 2 SE
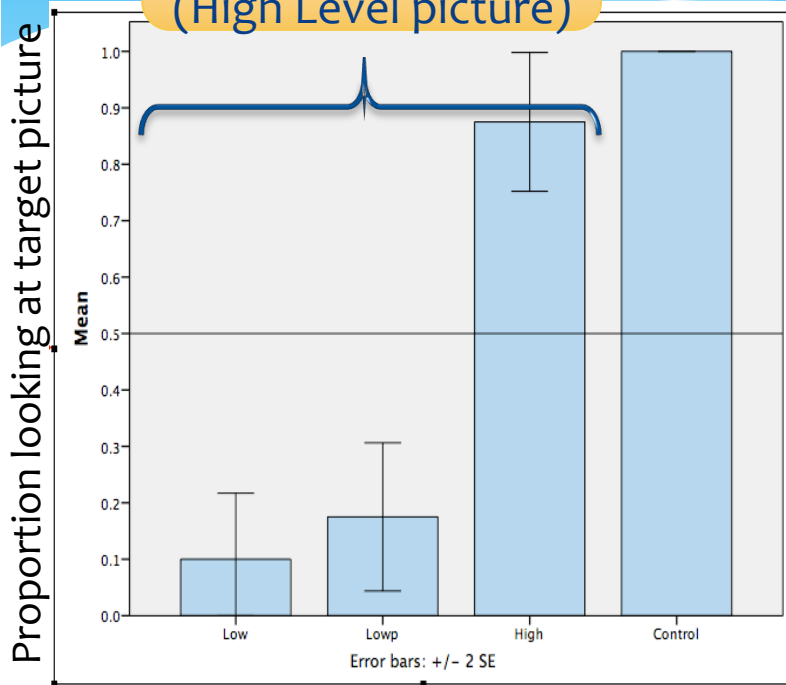
Once again, pointing results follow gaze results: preference for high attachment, even when strong cues such as pause militates against it.

* Significant main effect of Level (F(3,54) = 80.42, p<.001)
* No significant main effect of Experiment version (F(1,18) <1)
* No significant interaction, Level*Experiment version (F(3, 54) = 2.01, p=.12)

discussion

* Subjects' behaviour was as expected for controls, showing that they understood the task

* Bias for whole word, regardless of prosodic cues

  * Confirms previous results (offline tasks with temporary ambiguity)

* Bias for high attachment, even in the absence of cues or when strong cues as pause militates against it (Lowp).

  * European Portuguese adults differ from English adults, but behave similarly to English children.

  * This result cannot be interpreted as a weight effect to balance IPs > EP does not allow an IP boundary after the verb for weight effects (Elordieta et al., 2005), unlike in Catalan (Prieto, 2005)

conclusion

* Current results suggest 2 default processing strategies
  * Word processing differs from Phrasal processing

Prosody is not enough

* Ongoing work:
  * Look at language development data
    * Younger infants are more sensitive to prosodic cues and use them, at least at the word boundary level

acknowledgments

* All participants.
* Vasco Águas Oliveira for helping with images.
* Dr Joseph Butler & Dr Marisa Cruz.

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