Brain response to intonational phrase structure is purely prosody-driven

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Phrase-level prosody plays a fundamental role in language processing, as shown by studies on lexical access (Christophe et al. 2004), syntactic ambiguity resolution (Millotte et al. 2007), or artificial grammar learning (Langus et al. 2012). It is also crucial to language acquisition, as demonstrated by work within the prosodic bootstrapping approach (Jusczyk 1997, Hohle 2009). Intonational phrase boundaries (IPB) cue major speech chunks, which typically coincide with syntactic boundaries. The Closure Positive Shift (CPS) has been identified as a reliable ERP component that indexes the perception of IPB (Steinhauer et al. 1999, Pannekamp et al. 2005). However, in adult and developmental studies on the CPS, the nature of the component has been under debate. Pannekamp et al. (2005) have argued that the CPS is triggered by prosodic information only, given that it is found in utterances with reduced linguistic content. By contrast, recent ERP studies (Mannel et al. 2013) have suggested that the CPS is driven by knowledge of syntactic structure, since an adult-like effect only emerges by age 3 in German-learning infants. Importantly, behavioral studies have underlined cross-linguistic differences in IPB processing involving the weighting of boundary cues (Seidl 2007, Wellmann et al. 2012). In such studies, it has been shown that German 8-month-olds behave like adults (Wellmann et al. 2012). The current study investigates the CPS as a marker of IPB perception in European Portuguese (EP), a language with sparse pitch accent distribution where pitch movements combined with boundary lengthening (Frota, 2014) are mostly confined to IP edges. By using delexicalized stimuli with no syntactic information, we directly address the debate of whether the CPS is, or not, purely prosody-driven.

Methods. Twenty-four healthy, right-handed, native EP speakers (17 women, age range: 18-39 years, mean age: 27 years), participated in the study in exchange for a small gift. Stimuli consisted of naturally sounding 54 utterances with an IPB (WB) and 54 with no IPB (NB), obtained from MBROLA manipulations of 9 natural SVO sentences by replacing all syllables in a given sentence by the syllable /ba/, /na/, /mi/, /ti/, /pu/, /lu/ (9x6) while the sentence's prosody was preserved (Fig.1). Acoustic analysis of the stimuli shows significant differences in pitch range and duration of the boundary syllable (Table 1) between conditions, and pauses did not occur in WB or NB. The 108 sound stimuli were delivered aurally in pseudo-randomized order with an inter-stimulus-interval of 2000ms, using E-Prime software. Stimuli were divided in three blocks. The sequence of the blocks was randomized. The experiment lasted ~20min, with a pause between blocks. Participants were instructed to avoid eye blinking and other body movements during stimulus presentation. To minimize eye movements, they were asked to blink when an eye image was displayed in the center of a monitor 2s before each stimulus onset. The EEG was continuously recorded from 30 cap-mounted active Ag/AgCl electrodes (Neuroscan, 500Hz, LF0.05Hz, HF40Hz, Notch50Hz). ANOVAs for the midline electrodes were performed considering the two conditions (NB and WB) and electrodes (Fz, FCz, Cz, CPz, Pz) as factors. Further analyses included the lateral sites with Hemisphere (left, right) and location (anterior, posterior) as factors.

Results. Visual inspection of the average ERP responses revealed a positive shift that peaks around 500ms after the IPB (Figure 2). A main effect of condition was significant in the time window 1250-1500ms from sentence onset overall the scalp, but more centrally distributed (midline – Table 2). Both distribution and latency relative to IPB are in line with previously described CPS responses.

Discussion. A CPS was identified in response to an IPB in delexicalized utterances with no syntactic information. We therefore conclude that brain responses to IPBs are purely prosody-driven. This finding has implications for prosodic bootstrapping approaches of the interaction of prosody and syntax in language acquisition.

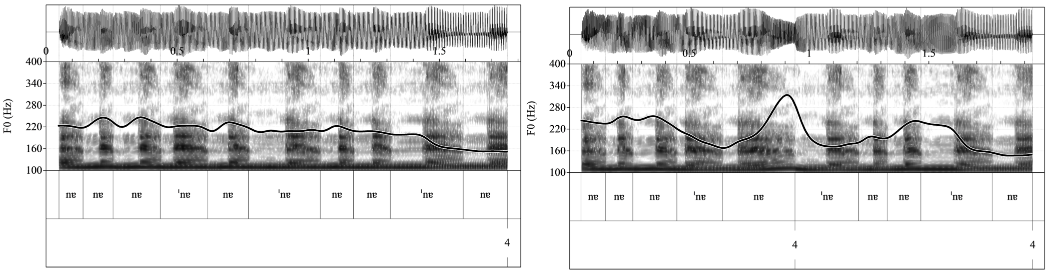

Fig. 1. Representative prosodic patterns of manipulated utterances without (left) and with (right) an internal IPB. Phonetic transcription is given in the first tier; IPBs are marked in the second tier.

Condition	Mean	Std. Deviation	t-test
NB_pitch range	8,69	6,66	-47,78, *p*<.001
WB_pitch range	113,84	17,17	
NB_duration	167,22	36,76	-24,12, *p*<.001
WB_duration	351,89	80,68	

Table 1. Acoustic analysis of the stimuli.

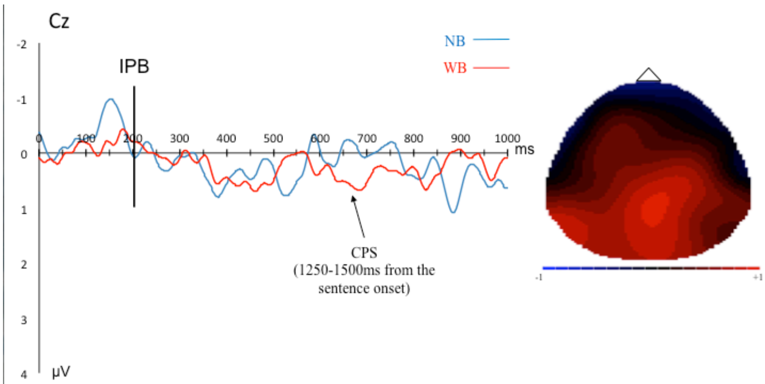

Figure 2. Grand mean ERP and scalp distribution on the Midline electrode (Cz) to the no boundary (blue line) and with boundary (red line) conditions. ERP waveformes referred to ~200ms before the IPB. Zero corresponds to 700ms after sentence onset.

	1250-1500 ms time window	
ANOVA midline	Amp (µV), mean	*F* and *p* values
Main effect of IPB	NB=0.46 WB=0.77	F(1,23)=15.48, p<.001
Interaction IPBxMidline		F(4,92)=1.79, p=0.19
ANOVA lateral	Amp (µV), mean	F and p values
main effect of IPB	NB=0.74 WB=1.00	F(1,23)=4.55, p<.05
Interaction IPBxHem.		F(1,23)=1.98, p=0.17
Interaction IPBxAP		F(1,23)=1.39, p=0.25

Table 2. Effects of ANOVAS for mean amplitudes in the TW 1250-1500 from sentence onset

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