Reading aloud: eye movements and prosody

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1. Eye movements and reading speech

The reader and the reading processes have been studied for years in a psycholinguistic perspective and a lot is known about what is involved (Perfetti, 1999; Vellutino, 2006). However, there is still much to learn considering interrelated processes and behaviors, which have been separately studied. Silent reading and reading aloud inform us in different ways about linguistic processing, comprehension and fluency. Tools and measures to deal with underlying cognitive processes are specific for each modality.

Eye movements provide measures that can indicate some linguistic properties of the text (Rayner et al. 2005):

- First fixation in a word varies according to orthographic, phonological and morphological properties, reflecting specific processes to visual word recognition.

- First pass, which includes FF and other fixations before moving the eyes to right or left regions, could tap the processes involved in lexical access of less frequent or longer words, required for their integration in a larger meaning or structural unit.

- Total time of word fixation, including all fixations in a word, must reflect word integration in a semantic-discursive mental representation, and can be taken as a window for *wrap-up* effects.

Reading speech, or speech produced in reading aloud, is strongly constrained by the communicative context, reader experience and text properties, such as vocabulary, syntactic structures, punctuation and layout. In reading speech, prosody is an important window to study phrasing processes and to relate them with syntactic parsing. To identify prosodic boundaries as important *loci* to study linguistic processing we consider two acoustic parameters (Gussenhoven & Rietveld 1992):

- Stressed vowel length, as a marker indicating the proximity of a high level prosodic boundary: the longer the time vowel duration is, the higher the boundary.

- Fundamental frequency of the stressed vowel, as an indicator of the syntactic position of the word: the more the word is embedded in the phrase or sentence the higher frequency on the stressed vowel.

2. Hypothesis

H1 Text complexity has an impact on visual reading time (fixations) and on reading speech time (speech and silent pauses).
Longer values for reading time variables (eyes and voice) are expected in a more complex text.

H2 Syntactic and discursive boundaries, as *loci* for structure building and information integration, respectively, trigger changes in prosody and in eye movements.
Increased fixation time and stronger prosodic indicators at discourse than at syntactic boundaries are expected within and between texts.

H3 Variables from eye movements and speech may be correlated to signal structure building and information integration.

3. Experiment

Aims

- Identify processes of linguistic information integration undergoing in oral reading for understanding.
- Verify the effect of linguistic and discursive properties of texts on language processing, considering their complexity level.
- Find related measures of prosody in reading aloud and in eye movements in order to contribute for reading fluency assessment and teaching.

Participants

17 European Portuguese native female speakers, students, proficient readers.

Procedure

Eye movements were recorded with a SMI IVIEW X™ HI-SPEED system, at a 1250Hz speed, and sound was recorded with a Logitech® Webcam Pro 9000.

Stimuli were divided, for presentation, into two blocks of text, font in size 22, Courier New, with two paragraphs spacing between rows, in a 17-inch screen.

After reading each text participants answered a multiple-choice questionnaire, thus ensuring a reading comprehension task.

Stimuli

Two informative texts, similar in word number (200), syntactic and information structure and layout:

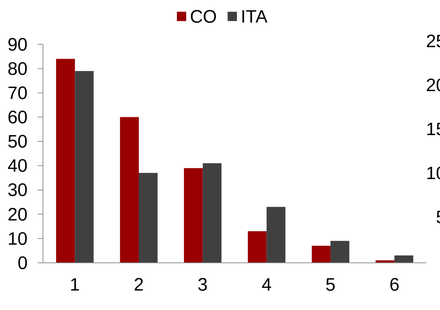
CO: An easy text about a Lisbon neighborhood

ITA: A hard text about thermo-acoustic proofing

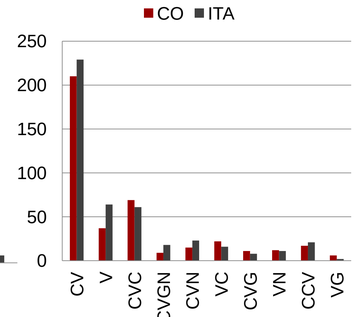
Thematic dimension as well as some word properties crucially contribute to differentiate the level of complexity of texts.

Word properties in each text were controlled considering: number of syllables, type of syllables and word frequency, with tools for automatic linguistic processing – FreP and CRPC (Graph 1, 2 and 3).

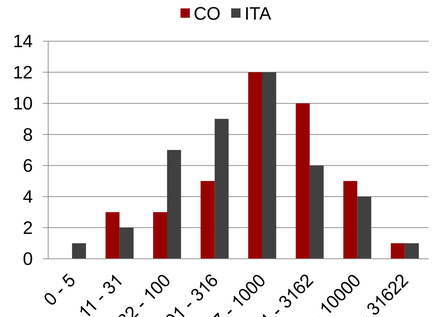
Graph 1: Syllables per word



Graph 2: Syllable types



Graph 3: Three syllable words frequency



Independent variables

Text

Familiar topic **CO:** About a Lisbon neighborhood

Unfamiliar topic **ITA:** About thermo-acoustic proofing

Position

Syntactic boundary (SB)

Target word in the right periphery of an NP

*Um aspecto interessante deste **bairro** deve-se*
*'An interesting aspect of this **neighborhood** is due'*

Discursive boundary (DB)

Target word in the right periphery of a sentence

*nas suas ruas de passeios **largos.***
*'in its **wide** sidewalks streets.'*

Head Phrase (SN)

Target word: a nominal head of an NP

*A **vida** deste bairro mundano*
*'The **life** of this mundane neighborhood'*

Dependent variables

Eye movements analysis

First fixation (FF)
First pass (FP)
Total time of word fixation (TTF)

Speech acoustic analysis :

Stressed vowel length(SVL)
Fundamental frequency of the stressed vowel (F0)

4. Results

Results for text

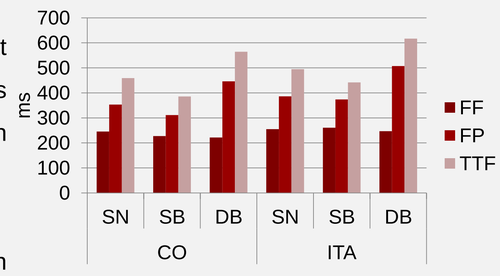
Eye movements

- Results show a strong effect of Text, with significant differences between the 2 texts in all dependent variables (FF p=0.02; FP p=0.001; TTF p=0.001), with lower times in CO than in ITA (Graph 4).

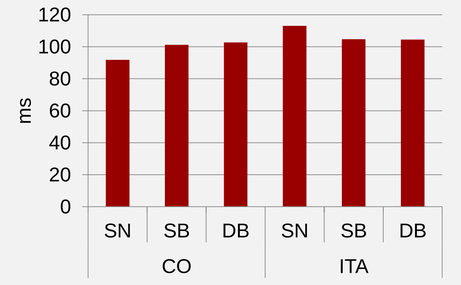
Reading speech

- We find a Text effect in SVL (Graph 5) with lower values in CO than in ITA (p<0.001).

Graph 4: *Mean values (ms) for visual reading variables (FF, FP and TTF) by Text (CO, ITA) and by Position (SN, SB, DB).*



Graph 5: *Mean values for "reading speech" variable SVL for both texts, by Position (SN, SB, DB).*



Results for Syntactic and Discursive positions

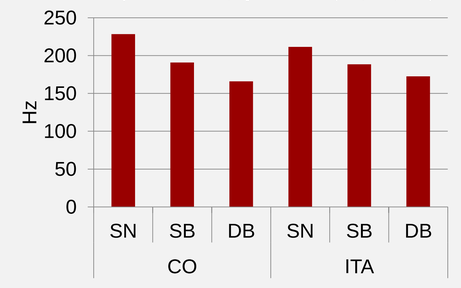
Eye movements

- Position effect in FP is clear when comparing SN and DB (p<0.001), SB and DB (p<0.001), with longer reading times for DB in both cases. A Position effect is consistently registered in TTF: SN higher than SB (p=0.03) and lower than DB (p<0.001); SB lower than DB (p<0.001) (Graph 4).

Reading speech

- There is no Position effect in SVL, however we find an interaction between Text and Position in SVL (p<0.001).
- Considering F0 declination in European Portuguese, an expected Position effect in F0 is verified, being SN higher than SB (p<0.001) and than DB (p<0.001), and SB higher than DB (p<0.001) (Graph 6).

Graph 6: *Mean values for "reading speech" variable F0 for both texts, by Position (SN, SB, DB).*



5. Conclusions

The different complexity of the two texts and its impact on linguistic processing was confirmed. The hypothesis of readers' responsiveness to linguistic and discursive complexity is sustained by evidences coming from speech and eyes.

Discursive Boundary is the *locus* where processes related with structural building ending and prosodic phrasing occur: the eyes take longer to complete the structure and possibly resume prior information, while speech signals the most embedded nominal head of an NP with higher F0, which declines as the information is being integrated, with the lowest values on the periphery of the sentence.

Lengthening of the stressed vowel and first fixation seem to be responsive to lexical properties.

Fundamental frequency and First Pass seem to reveal structural building, integration of information and possibly wrap-up effects.

References

Gussenhoven, C. & T. Rietveld, "Intonation contours, prosodic structure, and preboundary lengthening," *Journal of Phonetics, vol. 20, pp. 283-303, 1992.*

Martins, F., M. Vigário & S. Frota. 2016. *FreP - Frequency in Portuguese*. Version V2016. Software in CD-ROM.

Multifunctional Computational Lexicon of Contemporary Portuguese, available at http://www.clul.ul.pt/en/resources/88-project-multifunctional-computational-lexicon-of-contemporary-portuguese

Perfetti, Ch. "Comprehending written language: the blueprint of the reader," In C. Brown and P. Hagoort (Eds.), *The neurocognition of language. Oxford University Press, pp. 167-208, 1999.*

Rayner, K., Juhasz, B. & A. Pollatsek, "Eye movements during reading," In M. Snowling and C. Hume (Eds.) *The Science of reading:a handbook. Oxford: Blackwell Publishing Ltd, 79-97, 2005.*

Vellutino, F. "Literacy: Reading (Early Stages)," *Encyclopedia of Cognitive Science, 2006.*

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