Does listening to non-linguistic rhythm impact speech production?

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Leonardo Contreras Roa[1], Paolo Mairano[2], Joséphine Lacroix[3], Romane Riegler[3], Caroline Moreau[4], Anahita Basirat[3]
(1) CORPUS (EA 4295), Université de Picardie Jules Verne, France
(2) STL (UMR 8163), Université de Lille, France
(3) SCALab (UMR 9193), Université de Lille, CNRS, CHU Lille, France
(4) LilNCog (U1171-2), Université de Lille, CHU Lille, Inserm, France

Introduction

A growing body of evidence suggests that exposure to rhythmic auditory patterns (i.e. **rhythmic priming**) can modulate the processing of subsequently heard speech at various levels: phonological accuracy (Cason & Schon, 2012), word and sentence production (Cason et al., 2015; Zhang & Zhang, 2019), and grammatical and syntactic correctness (Przybylski et al., 2013; Kotz & Gunter, 2015).

This effect has been associated to three underlying mechanisms common to speech and music processing: precise auditory processing, neural entrainment to external stimuli and sensorimotor coupling (Fiveash, *et al.*, 2021).

In the current study, we aimed to test whether non-linguistic rhythmic priming has an effect on speech production and extends to prosody.

Method

13 native speakers of French (aged 55-83, 8 female, 5 male → 7 with Parkinson's disease and 6 healthy control participants) read aloud 45 sentences under three conditions:

- After listening to a **regular rhythmic prime** consistent with the stress pattern of the sentence.
- After listening to an **irregular rhythmic prime** inconsistent with the stress pattern of the sentence. (Figure 1)
- After listening to two seconds of **silence** (no prime).

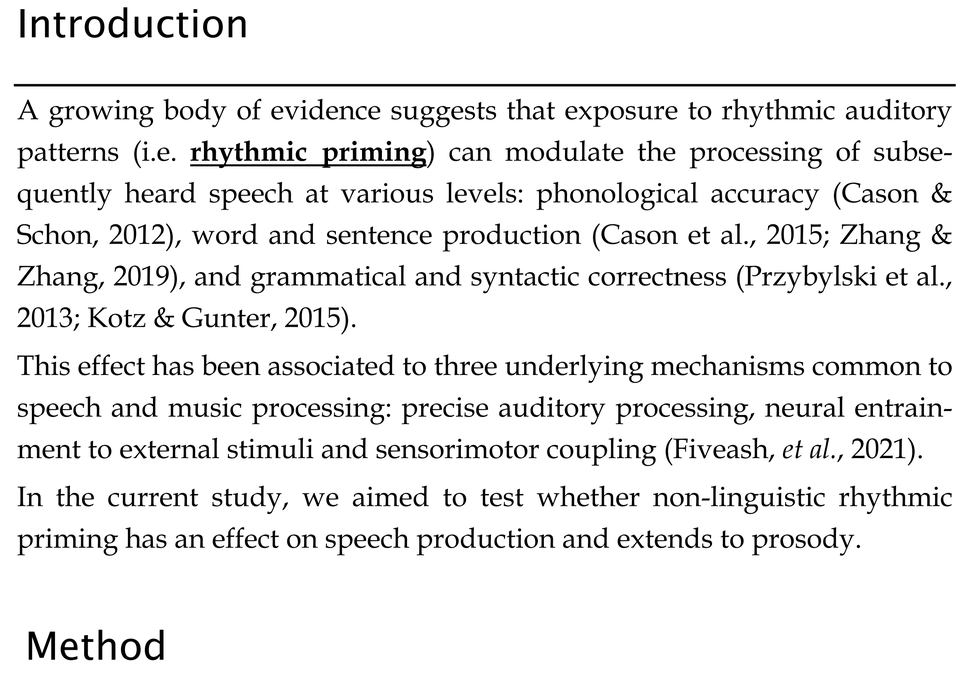

Figure 1: Regular and Irregular primes

Sentences contained 4 groupings of 3 syllables, totaling 12 syllables organized following a prosodic hierarchy (Figure 2). Groupings of 3 syllables were stressed on their **last one** as is usual in standard metropolitan French.

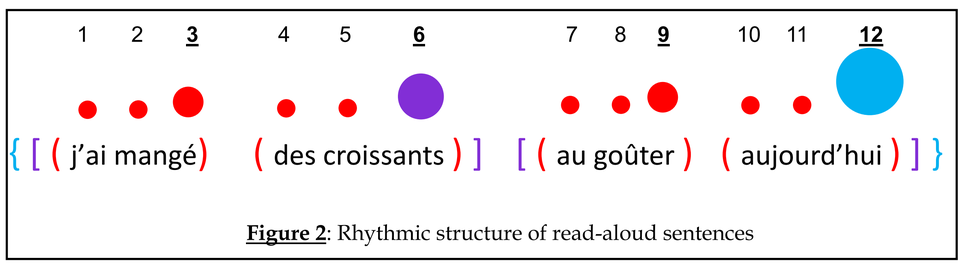

Figure 2: Rhythmic structure of read-aloud sentences

Recordings were semi-automatically transcribed (Kisler *et al.*, 2017) and syllabified (Reichel & Kisler, 2014), and three types of acoustic data were extracted and calculated:

1. Reading latency, i.e. the span of time between the end of the prime and the beginning of elocution.
2. Prosodic prominence, automatically detected through F0 and duration measurements with Prosoprom (Goldman & Simon-Hustinx, 2020)
3. Acoustic rhythm metrics (Lowit *et al.*, 2018), based on the distribution of vowel and consonant intervals:
   - **%V**: Percent of utterance duration composed of vocalic intervals
   - **varcoV**: Standard deviation of vocalic intervals divided by mean vocalic duration (×100).
   - **varcoC**: Standard deviation of consonantal intervals divided by mean consonantal duration (×100).
   - **nPVI-V**: Normalized pairwise variability index for vocalic intervals. Mean of the differences between successive vocalic intervals divided by their sum (×100).
   - **rPVI-C**: Pairwise variability index for consonantal intervals. Mean of the differences between successive consonantal intervals.

Results

Reading Latency

Latency distributions are shown on Figure 3. Latency means proved significantly the lowest after listening to a REGULAR PRIME, whereas there was no statistical significance between the NO PRIME and IRREGULAR PRIME conditions.

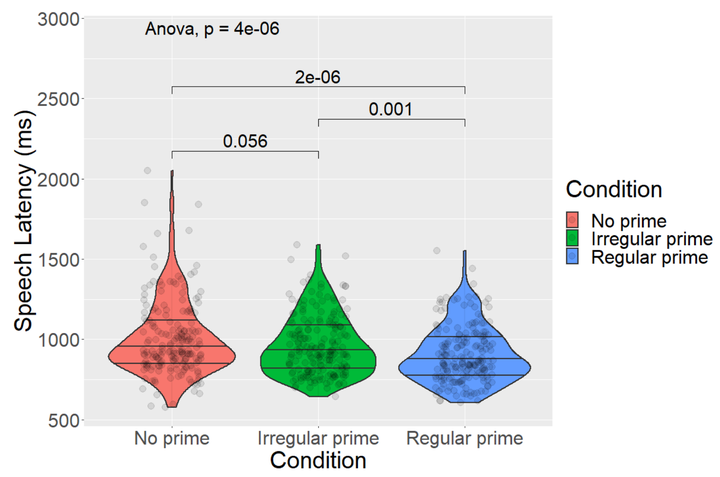

Figure 3: Reading latency by priming condition

Prosodic Prominence

No marked differences were found at a prosodic level at the expected prominent syllables (3, 6, 9 and 12) through the use of Prosoprom.

Prominences were detected in similar proportions in all three conditions (Figure 4), and the acoustic correlates responsible for the detected prominences were marginally different by condition (Figure 5).

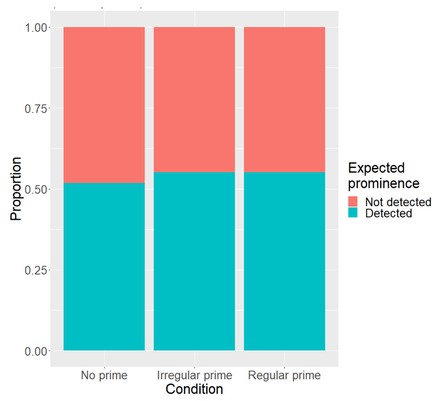

Figure 4: Prominence detection at expected syllables (Prosoprom) by priming condition

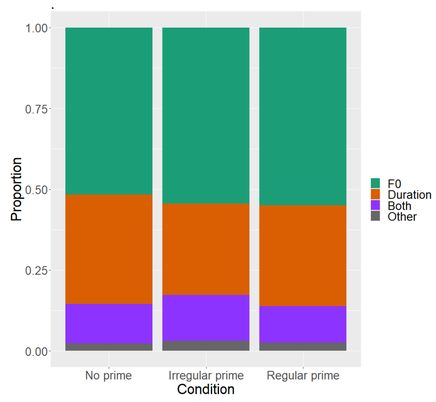

Figure 5: Acoustic correlates associated to prominence detection by priming condition

Rhythm metrics

Pairwise variability indexes (CrPVI and VnPVI, Figure 6) show biggest differences between the NO PRIME and IRREGULAR PRIME conditions, mainly throughout vocalic interval variations.

Standard deviations of interval durations (varcoC and varcoV, Figure 7), on the other hand, show more important differences between the NO PRIME and the REGULAR PRIME conditions, both at a vocalic and a consonantal level. Differences across the consonantal axis were also found between the NO PRIME and IRREGULAR PRIME conditions.

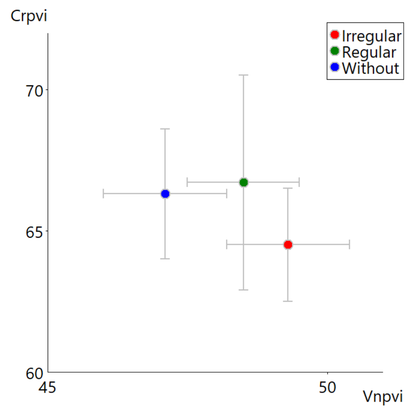

Figure 6: CrPVI vs. VnPVI by priming condition

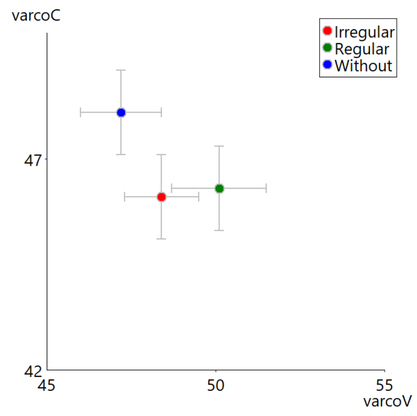

Figure 7: varcoC vs. VarcoV by priming condition

Discussion

The most striking result of our study was the correlation between regular priming and shorter **speech latency**, which points towards there being a link between the perception consistent rhythmic patterns and speech planning. This relationship could be further explored to develop therapeutic uses of rhythm for people with speech pathologies or innovative teaching techniques to promote first or second language acquisition.

The lack of **prosodic prominence** differences across conditions went against our hypotheses, but we only targeted expected prominent syllables. Analyzing the global distribution of prominences throughout the sentence might shed more light on these findings.

Variations in **rhythm metrics** need to be complemented with perceptive tests in order to assess the degree of influence of these differences on the intelligibility and comprehensibility of speakers.

Finally, it is worth noting that these results are part of a broader project exploring the impact of rhythmic priming on the speech of people with Parkinson's disease; however, this variable was not taken into account in the present study.

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Acknowledgements

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