On the production and perception of rhythmic patterns: an experimental study on Brazilian Portuguese lexical stress

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Introduction

The main purpose of the present study is to contribute to the understanding of how rhythmic patterns in human natural languages are produced and perceived. A point of great interest to this issue is the active role of acoustic parameters and gestural configurations involved in production and perception of rhythmic patterns, without the *a priori* assumption that rhythm is both produced and perceived through the same acoustic and articulatory correlates.

This study is divided in two parts: the first one focuses on **perception**, and the second on **production**. Both parts will be briefly addressed, although only the first one has been completed to date. The results reported are still preliminary. The analysis to be developed relies on complementary principles borrowed from usage-based models [1] [2], cognitive linguistics [3], exemplar theory [4] [5] and connectionism [6] [7].

PERCEPTION

[Common to all perception experiments]
Subjects: 22 BP native speakers **Devices:** laptop, noise-cancelling headphones

Experiment 1

Aims: to test the influence of language-specific patterns on the perception of non-linguistic rhythmic patterns.
Stimuli: non-linguistic; eight kinds of three-tone sequences, varing in frequency, duration or intensity.
Task: subjects had to choose among four given figures the most representative to the auditory pattern they heard.
Results and discussion: (cf. FIG. 1)
(1) strong prevalence of W-W-S pattern in frequency sequence. This tendency can be related to BP intonation, which typically assigns dominance through pitch to the last constituent of higher level prosodic domains.
(2) prevalence of W-S-W pattern in duration + intensity sequence and, to a lesser extent, in frequency + duration sequence. This tendency can be related to BP lexical stress, most frequently assigned to the penultimate syllable of a word and is mainly related to duration increments.
(3) prevalence of S-W-W pattern in frequency + intensity sequence. When the three parameters were simultaneously altered, there was no marked tendency.

Experiment 2

Aims: to test the influence of token and type frequency on the perception of ambiguous syllabic sequences
Stimuli: linguistic; sequences of syllables whose continuous repetition could lead to ambiguous parsing (either a S-W or a W-S pattern).
Task: subjects had to report the word they heard.
Results and discussion: (cf. FIG. 2)
(1) Pairs of words with *dissimilar* token frequency values: strong tendency towards perception of the most frequent word of the pair. As expected, token frequency influenced the parsing of ambiguous sequences.
(2) Pairs of words with *similar* token frequency values: some presented a tendency towards the S-W pattern and others, towards the W-S pattern. In this case, it was expected that type frequency could have an effect on the perception of the words and penultimate stress (S-W), which is the most frequent pattern on BP, would be preferred over ultimate stress (W-S). However, this was not found.

Experiment 3

Aims: to investigate the categorization of stress patterns.
Stimuli:10 pairs of words differing only in stress position, manipulated through a morphing algorithm [8] in 11 degrees, resulting in 110 stimuli.
Task: subjects had to report the word they heard.
Results and discussion: (cf. FIG. 3)
Results show that the categorization of words according to their stress pattern is subject to an abrupt change, which corresponds to the boundary between categories. This change tends to occur in the middle of the levels for words with similar token frequency, but is shifted rightwards or leftwards in words with dissimilar token frequency counts. In the last case, the most frequent word of the pair occupies a greater perceptual space than the less frequent one.

PRODUCTION

Experiment 4

Aims: to investigate (1) influences of stress and accent on the glottal activity and (2) interaction of glottal and acoustic parameters.
Subjects: Four BP native speakers.
Devices: two-channel electroglottograph (EGG); head-worn microphone, Optotrak motion tracking system
Stimuli: four test-syllables ([ga, ku, pa, pi]) equally represented by 32 three-syllable words varying in stress degree (stressed, prestressd and postsressed). The same sentences were pronouced in both neutral and focus accent.
Measurements: (acoustic) duration, overall intensity, spectral emphasis; (EGG) F0, contact quotient (Cq), speed index (SI), closing phase (Cp) and opening phase (Op). The Optotrak measurements are still being carried.
Statistics: Two-way Analysis of variance with Stress (3 levels) and Focus (2 levels) as independent variables.
Results and discussion:

Articulatory parameters are affected by stress and focus, although in a lesser extent than acoustic ones. The interaction between acoustic and articulatory parameters is not one to one, in the sense that many acoustic tendencies identified are not a result of the articulatory parameters tested, whereas some articulatory tendencies did not have an effect on acoustic parameters.

The folowing parameters were significant, for each factor evaluated:
- Stress: duration, intensity, spectral emphasis, Cp (subjects G, J)
- Focus: duration, F0, intensity (subject J and V), opening phase (subject J).

Conclusions

With this series of interrelated experiments, we expect to contribute to the study of Brazilian Portuguese rhythm with new and reliable data. With the analysis to be developed, we intend to investigate to what extent usage-based models, cognitive phonology, exemplar theory and connectionism can be brought together in a complementary way to achieve a comprehensive and robust model in phonology and prosody.

The experiments presented above address fundamental assumptions of cognitive linguistics and usage-based models. Specifically, the results from the perception experiments can be used to support the claim that language is a constitutive and integrated part of human cognitive system (Exp 1) and that linguistic use has an impact on rhythm processing and categorization (Exp 2 and 3), in accordance with the broader assumption that experience shapes representation.

From the production experiment (Exp 4), we can preliminarly conclude that word stress and accent in BP can be related not only to acoustic properties but to glottal articulatory configurations, even though the alignment between these two dimensions is not a direct one.

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Ongoing research; any comments and suggestions are welcome!

FIG 1

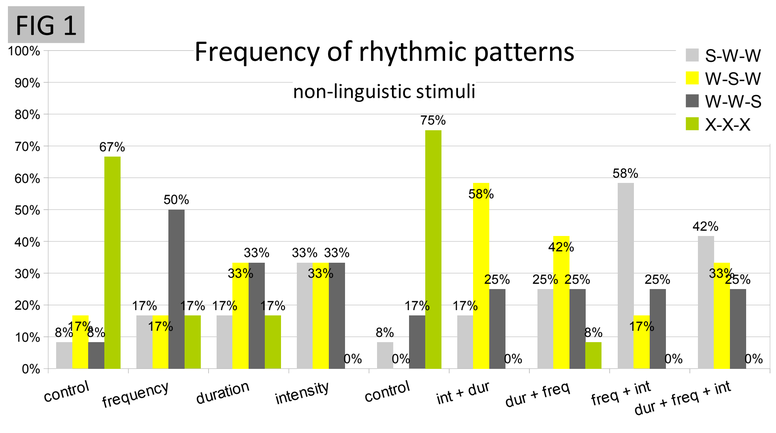

FIG 2

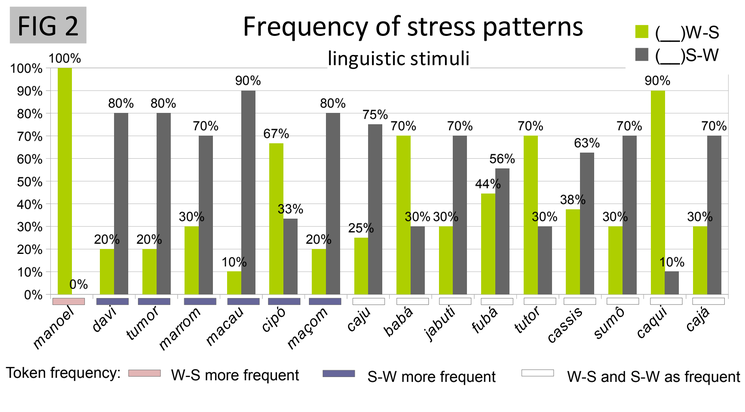
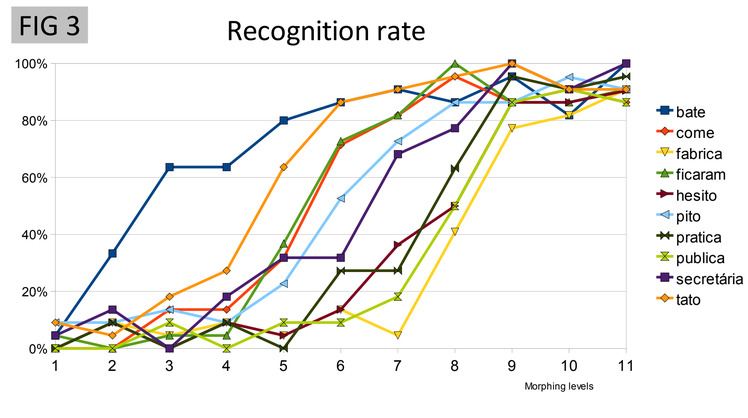
FIG 3