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Prolongation in Romanian

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Abstract

In this study we investigate segmental prolongation (PR) as a form of disfluent hesitation in a corpus of spontaneous Romanian monologues. A total of 3541 PRs were extracted from 216 minutes of speech pertaining to 4 native speakers (2 female, 2 male). In line with the methodology employed by previous corpus-studies on PR, our data reveal that prolonged segments have an average duration of 316ms (sd = 130), surfacing at a frequency of 11.3 per 100 words and following a 17–7–76% position distribution. In Romanian, all segments can undergo PR, with vowels being the preferred target (57.2%), followed by fricatives (12.8%), nasals (11.8%), plosives (10.3%), diphthongs (5.5%), affricates (1.6%) and laterals (0.8%). The vast majority of PRs surface in monosyllabic words (59%). Function words are prolonged in 57% of the cases. By including data from a lesser-studied European language, this paper broadens our understanding of the formal regularities of PR in a cross-linguistic setting.

Index Terms: prolongation, Romanian monologue speech, spoken corpus.

1. Introduction

1.1. Research background

Initially studied as a stuttering-distinctive disfluency, typically accompanied by muscular tension [1, 2], prolongation (PR) has also been observed to frequently surface in non-pathological speech, serving as a 'longer time-buying device' [3] in face-to-face conversation, alongside other forward-looking disfluencies [4]. Prolonged segments have been defined as "phones that are longer than should be expected in normal-paced, fluent, speech" [5, p. 163], thus posing a challenge in identifying them in speech based solely on perception [6]. As a means to address this issue, some studies have employed a lower limit (e.g. 200ms by [7]). Nonetheless, a universally agreed-on threshold has not been put forward due to speaker-specific PR temporal patterns as well as language-specific factors as highlighted by various corpus-based analyses [9–16] and speech synthesis studies [17, 18]. Standalone PRs are rare in spontaneous speech [17], as prolongation mostly appears in complex disfluent sequences [4, 5, 8].

1.2. Aim of this study

This study examines prolongation in Romanian monologue speech defined as a hesitation-type disfluency [19] with the goal of identifying features that are particular to the language as well as those that are common across languages, by contrasting our findings with prior research on genealogically (un)related languages. As such, our research questions are: (1) Does Romanian spontaneous speech data follow the same distribution and temporal patterns related to PRs observed in other languages?, and (2) To what extent do our data align with the 'morphology [5]/phonotactics [16] matters' hypothesis? More precisely, to what degree do phonotactics and syllabic structure influence the occurrence of PR in the language?

2. Methodology

2.1. Data

This paper investigates PRs in Romanian connected speech based on data derived from the Ro-Phon corpus [20]. The corpus consists of 20 monologues (10 female and 10 male speakers, non-pathological speech) organized around three main conversational topics related to past (memories), present (pursuits), and future activities (forthcoming projects). Participants could move freely from one topic to another, always addressing the same female researcher. Recordings were made in a sound-attenuated room, under identical conditions, using a stand-mounted microphone placed at a fix distance from the participant's mouth, with a default sampling rate of 44100 Hz (mono channel). All participants were native monolingual speakers of Romanian, sharing the same geographical and socio-economic background. The first module of the corpus (recorded in 2020) gathers speakers aged 30 to 45 years old, while the second module (recorded in 2024) includes speakers above 50 years old. Contributing to the documentation of a lesser-resourced Romance language, the Ro-Phon corpus presents a detailed annotation schema for disfluencies [19], pauses [21] and non-verbal vocalisations [22]. All recordings are manually aligned in PRAAT [23]. Our current study is conducted on 4 monologues pertaining to 2 male and 2 female speakers, ages 36 to 45, resulting in 3.6 hours of speech.

2.2. Analysis parameters

In line with [8] and subsequent corpus-studies on prolongation [4–6, 9–16], we examined our data according to:

- *frequency of occurrence* – calculated in ratio per 100 words (including fillers, onomatopoeia, repeated and cut-off words, without differentiating word type/token) as well as in ratio per minute of speech (including pauses of various types); when more than one PR was identified in a single word (e.g. [ˈmːulteː] 'many'), each prolonged segment is annotated separately; prolonged filler particles [24] are not examined as PRs.
- *position* – we distinguished between initial (first segment in a word, e.g. [ˈfːo̯arte] 'very'), medial (a segment in a word which is neither first nor last, e.g. [aniˈmːalele] 'the animals') and final position (last segment in a word, e.g. [ˈʦarəː] 'country'); when a prolonged consonant undergoes secondary palatalization (e.g. [paʃʲː] 'footsteps'), a feature which typologically individualizes

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Romanian among Romance languages [25], it is interpreted as being word-final; one segment cut-offs (e.g. *eu v:-…vreau*, 'I w…want'), labelled 'fragments', and monosyllabic words consisting of a single vowel (e.g. indefinite article /o/, auxiliary /a/), labelled 'VWrd', are both grouped under 'other';

- *segment type* – Romanian belongs to the Eastern Romance branch, being also part of the 'Balkan linguistic union' [26, 27]; in terms of vowel inventory, standard Romanian has seven phonemic monophthongs and two phonemic diphthongs [28]; Romanian has both rising and falling diphthongs; the language has 24 consonants, including the palatalized inventory and the 2 glides /j, w/ [29, 30]; stress patterns in Romanian have been shown to be predictable depending on prosodic word boundaries [28], with primary stress based on the right-edge prominence within prosodic words, while secondary stress, dependent on the location of primary stress, is assigned based on feet [25]; Romanian displays both syllable-timed language properties, such as little vowel reduction (e.g. Italian, French), as well as stress-timed language properties, representative of complex consonant clusters (e.g. English, European Portuguese) [25, 31]; all segments can undergo prolongation, without it being a contrastive feature [25, 28];
- *word type* – since the corpus is not POS-tagged, tokens with PRs were manually annotated for word type and POS; PR on interjections was not taken into account;
- *number of syllables and syllabic structure* – Romanian has complex consonant clusters, with the maximum complexity being C^3VC^3 [32] (three syllable-initial consonants, and up to three syllable-final consonants); we examined PR in terms of number of syllables (ranging from 1 to 7) and syllabic structure, differentiating among PRs in onset, nucleus or coda position;
- *duration (ms) of prolonged segments* – the Ro-Phon corpus uses a 200ms threshold on prolonged segments, as [7]; in our analysis, no threshold was employed;
- *gender* – we investigated whether PR rates and temporal patterns are dependent on the speaker's gender.

A total of 3541 PRs were extracted from the corpus via a script in PRAAT. Statistics and data visualization were carried out in R/Rstudio [33] and DATAtab [34].

3. Results

3.1. Prolongation rates

Our results suggest that PR varies depending on the speaker (Table 1), displaying an overall rate of 11.3 phw and 16.43 pmin (pauses included). These rates are much higher than previously reported. Possible reasons stem from language-related factors, whereby all segments in Romanian cand be prolonged regardless of their position in the word, the nature of the speech task (monologic data), but also from language independent factors, related to the methodology itself, where we did not rely solely on auditive perceptive criteria, but also employed a detailed acoustic analysis, based on the visual inspection of the spectrogram and manual segmentation.

Table 1: *Summary statistics on PR rates*

	S1	**S2**	**S3**	**S4**	∑
	female speakers		male speakers		
WrdT	9227	6385	7914	7831	31357
duration	66.33	40.26	48.47	60.40	215.46
PR	1129	713	868	831	3541
Ratio phw (%)	12.24	11.17	10.97	10.61	11.3
Ratio pmin	17.02	17.71	17.91	13.76	16.43

3.2. Position

As attested in previous corpus-based studies (results summarised in Table 2), PRs are not evenly distributed across initial–medial–final word position, with languages displaying, in various degrees, a preference for prolonged segments in word-final position. Hebrew [14], Italian [15, 16] and Mandarin Chinese [10] have a marked preference for prolonging word final segments (above 90%), while languages such as American English [8], Swedish [5] and Hungarian [11, 12] showcase a more uniform distribution. Tok Pisin [5] has no prolonged segments in word-medial position. Disfluent PR in German [13] typically surfaces on the last segment in a word, while accentuation PR has an almost balanced distribution between tokens in medial and final position.

Table 2: *PR ratios according to word position attested in previous corpus-based studies*

Language	**initial–medial–final position distribution**	
American English [8]	32–22–50%	(H – M)
Swedish [8]	31–18–49%	(H – M)
	24–17-58	(H – H)
[5, 6]	28–20–52%	
Tok Pisin [5]	18–0–83%	
Japanese [9]	10–5–85%	
	(excluding monomoraic words)	
Mandarin Chinese [10]	4–1–95%	
Hungarian [11, 12]	18–19–63%	(without 'a')
German [13]	7–15–78%	(disfluent PR)
	19–37–44%	(accentuation PR)
Hebrew [14]	1–1–98%	
Italian [15]	5–4–91%	
[16]	3–1–96%	
Romanian (current study)	17–7–76%	(excluding 'other')

Adding to this intricate display of PR distribution across various languages, the data from Romanian are markedly different from previous results, showing a 17.15–6.63–76.22 distribution ratio, by excluding 'fragments' and 'VWrds' (130 tokens). These results extend upon the 'morphology [5]/phonotactics [16] matters' hypothesis, whereby PR distribution within the word could be language specific due to phono- and morphotactic constraints. In this context, Romanian, with a C^3VC^3 syllabic structure [32], occupies an intermediate position between languages with complex consonant clusters, like Swedish (C^3VC^8 [5], C^3VC^9 [11]), German, and those with lower syllabic complexity, such as Japanese, Mandarin, and Tok Pisin (C^2VC^1 [5]). Moreover, by displaying complex consonant clusters, Romanian does not resemble Italian, showcasing a C^3VC structure [35 *apud* 16], though genealogically related.

3.3. Segment type

In terms of phone class (Table 3), PR in Romanian shows both language-independent features, such as vowels being the preferred PR target, similar to Mandarin Chinese [10], Hebrew [14], Hungarian [11, 12], though not as prevalent as the 90% distribution attested for Italian [15], as well as language specific traits, with nasals and fricatives (third most frequent in German [13]) occupying subsequent positions in the frequency distribution. Plosives, where PRs were annotated separately for the closure phase or for an aspiration of unusual length added to a word-final stop [13], are the fourth most frequent class, as opposed to Swedish [5], where plosives are frequently prolonged. Furthermore, prolonged plosives outnumber diphthongs in Romanian, thus contrasting with German

findings [13], where the hierarchy is reversed. Affricates and laterals have the lowest frequency in our data.

In terms of segment type, the most frequently prolonged vowel is /e/, same as in Hebrew [14], which often occurs in prepositions (e.g. *de*, *pe*), determiners and nouns (usually as a plural inflectional ending). Following in the hierarchy are the vowels /ə/, frequently occurring in *că* conjunction (second most prolonged word) or in nouns, mostly as an inflectional ending marking case, and /a/, which typically surfaces in prepositions (e.g. *la*) and adverbs. The top-five consonants are /n/, same as in German [13], /ʃ/, appearing in the conjunction *şi*, the most frequent word prolonged in our data, /t/, which is not attested in Italian [15, 16], but has the highest frequency in Swedish [5], followed by /m/ and /s/, similar to German [13]. As can be observed, the frequency of the top-five phones is not only phonotactically motivated, but also morphologically grounded.

Table 3: *PR in terms of phone class, with top 5 vowels and consonants displayed (all data pooled)*

Phone class	Count	% of total
vowels	2026	57.2
fricatives	453	12.8
nasals	417	11.8
plosives	364	10.3
diphthongs	194	5.5
affricates	57	1.6
laterals	30	0.8
Vowels		
e	593	16.7
ə	460	13
a	337	9.5
i	309	8.7
u	218	6.2
Consonants		
n	248	7
ʃ	242	6.8
t	190	5.4
m	169	4.8
s	131	3.7

Another aspect worth noting is that Romanian allows for a more flexible distribution of PRs compared to the restrictions in Hebrew [14], meaning that all segments can undergo prolongation regardless of word position.

3.4. Word type

In our analysis, nouns, adjectives, verbs and regular adverbs were considered content words (open class), whereas function words (closed class) comprise conjunctions, prepositions, function adverbs (semiadverbs, e.g. *chiar* 'even' [36], question words, e.g., *unde* 'where', *cum* 'how', and *da* 'yes', *nu* 'no'), inflection markers (e.g., auxiliaries, infinitive marker *a*, subjunctive marker *să,* comparative morpheme *mai*) and determiners. We included in the class of determiners all nominal functional categories [37], i.e. articles, demonstratives, pronouns, quantifiers. A salient feature of Romanian, differentiating it from other Romance languages, is the status of the definite article, which is not a word, but an enclitic bound morpheme, encoding not only definiteness, but also case [36]. Since definite articles have the status of grammatical endings, PRs occurring in this context were POS-tagged according to their base-words. The results for the POS analysis are presented in Table 4. In our dataset, function words are more frequently prolonged than content words, with a ratio of 57% to 42%. Our results support the more widespread claim that prolongation occurs more often in function words, as shown in the research carried out on German [13] and Hungarian dialogues [11, 12].

Yet, in some languages the distribution is almost 50-50, e.g. in Japanese [9], with a slight, but non-significant preference for content words in Swedish [5], and function words in Mandarin Chinese [10]; for Italian, conflicting studies indicate both content [15] and function [16] words as preferred PR targets. In our corpus, conjunctions were the most frequently prolonged part of speech (e.g. *şi* 'and'), similar to German [18] and Hungarian [11, 12], whereas in Italian [16] prepositions outnumber conjunctions. These findings show that PR occurs mostly at juncture points between and within sentences, thus indicating the role of prolongation in speech planning and signalling the cognitive load of the following segment [18].

Table 4: *PR in terms of word type*

Word type	Count	% of total
Content words/open-class words		
noun	633	17.88
verb	536	15.14
adjective	155	4.38
adverb	150	4.23
Function words/closed-class words		
conjunction	801	22.62
preposition	438	12.37
determiner	431	12.17
adverb	222	6.27
inflection	112	3.16
Other		
fragments	58	1.64
unassigned	5	0.14

3.5. Number of syllables and syllabic structure

Prolongation in Romanian targets monosyllabic words in 59% of the cases, lower than the 74.05 ratio reported for Hebrew [14]. Segment prolongation in polysyllabic words follows a similar trend reported for other languages [11, 12, 14], whereby the increase in syllable number attracts a lower rate of PR. In terms of syllabic structure, most PRs occur in a syllable's nucleus (61%), while prolonged onsets and codas exhibit a similar frequency of 17% and 22% each. These results show a marked difference from German disfluent PRs [13], which target nuclei (49.4%) or codas (43.6%). When examining syllable number as a function of word-type, we observe that speakers show a tendency of prolonging monosyllabic function words (49% of the cases), followed by polysyllabic content words (32%). Monosyllabic content (10%) and polysyllabic function words (9%) are the less preferred target for PR.

3.6. Duration

Prolonged segments in our data range from a 101 ms plosive to a 1077 vowel representative of the indefinite article /o/. Since no threshold was employed in our analysis, a higher temporal range was expected. By comparison, the 4 corpora analysed by Eklund for Swedish [5, p. 244] attested PR intervals (in ms) of 77–1239 in WOZ-1 (human–"machine"–human), 91–2454 in WOZ-2 (human–"machine"), 84–813 in the Nymans corpus (human–human), and 87–1138 for the Bionic data (human–machine). Most of our data (65%) are grouped between 200 and 400ms. The average duration of prolonged segments in Romanian is 316.05ms (sd = 130.09), placing it above the 239.9ms mean reported for German [13], as well as the PR time-based mean in Italian reported by [16], both in monologic (251ms, sd = 139) and dialogic data (290 ms, sd = 173). The mean duration of Romanian PRs is also higher compared to the 306ms (sd = 213) attested for Swedish [5], but lower than the average observed in Tok Pisin (347ms, sd = 170). The average

duration reported for Italian by [15] remains the highest, at 396ms (sd = 229). Temporal patterns of prolonged segments in Romanian spontaneous speech are given in Table 5 below.

Table 5: *PR duration as a function of the analyzed parameters (all data pooled)*

Parameters	Duration (in ms)	
Position	**Median**	**Mean ± Std.**
initial	256	286.6 ± 103.01
medial	220.5	230.2 ± 63.5
final	297	329.3 ± 134.7
VWrd	345	378.6 ± 167.95
fragments	276	294.7 ± 103.8
Phone class		
vowels	300	339.8 ± 139.6
fricatives	273	299.5 ± 97.5
nasals	259	292.4 ± 109.9
plosives	191.5	215.4 ± 83.4
diphthongs	368.5	379.4 ± 97.01
affricates	275	272.3 ± 89.4
laterals	243.5	240.9 ± 60.04
Word type		
content words	260	283.1 ± 108.55
function words	305	341.8 ± 139.4
fragments	282	299.9 ± 107.35
unassigned	218	232.2 ± 51.5
Syllable		
1 syllable	300	333.9 ± 137.9
2 syllables	266	296.2 ± 122.2
3 syllables	261	282.6 ± 99.05
4 syllables	259	285.4 ± 105.08
5 syllables	295	303.5 ± 106.04
6 syllables	339	337.9 ± 104.45
7 syllables	212	240 ± 51.1
onset	253	280.9 ± 105.1
nucleus	302	341.1 ± 137.9
coda	258	277.2 ± 108.9
Gender		
female PR	295	336.5 ± 148.5
male PR	275	294.8 ± 102.4

When analysing duration as a function of word position, a one-way ANOVA shows a significant difference between PRs in initial, medial and final tokens ($F = 82.69$, $\eta^2 = 0.05$, $p = <.001$), with final segments having the longest average duration. All pairwise comparisons are significant, according to the Bonferroni post-hoc test. Furthermore, a one-way ANOVA reveals a significant difference between the phone classes with respect to duration ($F = 68.48$, $\eta^2 = 0.1$, $p = <.001$). Pairwise comparisons based on post-hoc tests are significant for most classes, except for affricates vs. nasals, fricatives and laterals, plosives vs. laterals, nasals vs. fricatives and laterals, fricatives vs. laterals. As shown in Figure 1, there are temporal variations within each class, with diphthongs in initial and word-final position having the highest average duration in our data (474 and 378ms, respectively). The lowest mean duration was found in medial position plosives (178ms) and word-initial affricates

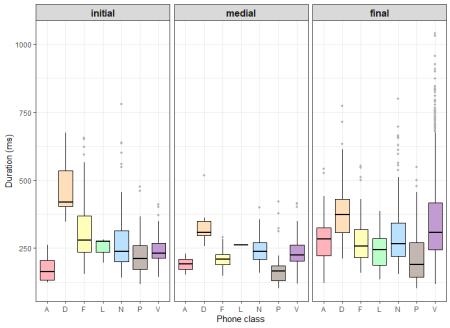

Figure 1: *Temporal patterns of PR in terms of phone class grouped by position in the word ('Phone class' is displayed in alphabetical order, where A = affricates, D = diphthongs, F = fricatives, L = laterals, N = nasals, P = plosives, V = vowels)*

(175ms). Our findings also point out that prolonged segments in diphthongs, averaging at 379ms (sd = 97), are significantly longer than PRs in vowels ($t(276.08) = -5.2$, $p = <.001$), with an average of 340ms (sd = 140), which, in turn, are longer than consonants ($t(3291.4) = 16.2$, $p = <.001$), scoring a mean duration of 272ms (sd = 103). A two tailed t-test showed that the duration of the prolonged segments inside function words is significantly longer than in content words ($t(3464.7) = 13.95$, $p = <.001$). As for duration as a function of syllable number, a two tailed t-test showed that PRs in monosyllabic words are significantly longer than in polysyllabic outputs ($t(3389.08) = 9.64$, $p = <.001$). Furthermore, a one-way ANOVA reveals a significant difference between the temporal pattern of the prolonged segments according to their position in the syllable ($F = 99.85$, $\eta^2 = 0.05$, $p = <.001$). The Bonferroni post-hoc test indicated that the prolonged nuclei differ significantly from the onsets and codas, whereas between the onset and coda positions, there is no significant temporal difference.

3.7. Gender

In our exploratory analysis, female speakers displayed a higher prolongation rate (11.8 phw, 17.3 pmin) then male speakers (10.8 phw, 15.6 pmin), which was significant according to a binomial test ($\chi^2(1) = 7.04$, $p = .008$ for PRs phw, and $\chi^2(1) = 9.21$, $p = .002$ for PRs pmin). With respect to the duration of the prolonged segments, in our data, women produced longer PRs (336.5ms, sd = 148.5) than men (294.8, sd = 102.4). A two-tailed t-test showed that this difference is significant ($t(3282.04) = 9.78$, $p = <.001$). Our results contrast with those attested for Hebrew [14], where men produced more and longer PRs than women, which was interpreted as yet another indication that, in conversation, men use more strategies to keep the floor. Yet, our dataset consisted only of 2 male and 2 female speakers, and the effect size was rather small ($d = 0.33$). Larger-sample studies are thus necessary to attest a significant trend.

4. Summary and outlook

In this study we have analysed the frequency and temporal patterns of disfluent segment prolongation in Romanian monologue speech. In line with our first research question, Romanian appears to follow certain preferences observed for other languages, such as PR occurring mostly on monosyllabic words, on vowels and on final word segments. Yet Romanian displays also language-specific features, such as PR of all phone types, with nasals and fricatives more frequent than plosives and diphthongs, and longer durations of the prolonged segments than the data reported for German, Italian [15] and Swedish. Our tentative analysis of gender patterns indicates that women use more frequent and longer PRs, unlike in Hebrew. With respect to the second research question, Romanian data support to an extent the 'phonotactics matters' hypothesis, whereby the position distribution is not as uniform as in languages with more complex consonant clusters (Swedish, German), nor is completely skewed toward final position, as in languages with similar low complexity (Japanese, Mandarin). Future work will examine the relation between PR rates and speech styles, by comparing PRs in monologues and dialogues, as wells as exploring the clustering of PR with filler particles and other disfluencies, in order to better understand the functions of PR in (dis)fluent speech. By including data from a lesser-studied Romance language, this paper broadens our understanding of the formal regularities of prolongation in a cross-linguistic setting.

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