

What is Raddoppiamento? Lengthening and Prosody in Italian¹

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1. Introduction

1.1 Definition of Raddoppiamento

(1) Raddoppiamento

Given a sequence of two words, word1 word2, the initial consonant of word2 lengthens when word1 ends in a stressed vowel.

- (2) città s:anta “holy city”
givedì b:ello “beautiful Thursday”

1.2 Goal of the paper

- Raddoppiamento has received much attention in phonological works. But, a firm empirical basis backing various phonological hypotheses is lacking.
- Our **goal** is to quantitatively document the Italian Raddoppiamento and test some of the segmental and suprasegmental factors that may condition its occurrence.
- Data is collected, measured and analyzed in a systematic way to test several hypotheses drawn from the literature on the topic.

1.3 Literature Review:

• Prosodic and syntactic constraints that prevent Raddoppiamento from taking place have been posited:

- syntactic constraints (Napoli and Nespors 1979): left-branching condition.

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| - prosodic constraints (Nespor & Vogel 1986): process is restricted to phonological phrase; across intonational phrase boundaries it is blocked. |
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- Phonological approaches to explain Raddoppiamento:
 - Vogel (1978): Raddoppiamento as resyllabification rule to meet well-formedness conditions in Italian.
 - Nespor and Vogel (1979): lengthening as a technique to avoid a stress clash.
 - Chierchia (1983-6): Raddoppiamento as the result of resyllabification rules operative in Italian.

- Common claim to phonological analyses:
 - stressed final vowels are short in Italian compared to non-final stressed vowels, which are long.
- Missing environment from previous works:
 - initial segment of word2 is a vowel.

1.4 Hypotheses to be tested

- Our hypotheses are related to the presence and degree of lengthening of the segments relevant in the process (final segment in word1 and initial segment in word2) with respect to three variables: stress, intonational boundary and identity of segments.

(3) Hypotheses:

a. Hypotheses testing the traditional environment for Raddoppiamento:

- 1- Initial consonant in word2 lengthens after a stressed vowel.
- 2- Initial consonant in word2 does not lengthen after an intonational boundary.

b. Hypotheses testing a new possible environment for Raddoppiamento:

- 3- Initial vowel in word2 lengthens after a stressed vowel.
- 4- Initial vowel in word2 does not lengthen after an intonational boundary.

c. Hypothesis testing claim assumed by Raddoppiamento accounts:

- 5- Final vowel in word1 does not lengthen when stressed relative to its unstressed counterpart.

- Acoustic data is collected in a controlled experiment and show that only hypotheses 1 and 4 hold.

2. Experimental Method

- A controlled experiment was designed to get acoustic data from native Italian speakers in order to test the hypotheses in (3).

2.1 Stimuli

- To test interaction of three factors (stress, intonational boundary and segment identity) each stimulus contained a particular environment according to the following criteria:

2.1.1 Stress

- first word in sequence word1 word2 is variably stressed in last syllable: final or non-final stress.
- word2 contains invariably initial stress.
- we get pairs of sentences like (4) where the environment is the same except for the stress of word1²:

- (4) La nostra è una **facoltà ibrida**. “Ours is a hybrid faculty”
È una **pianta ibrida**. “It’s a hybrid plant”

2.1.2 Boundary

- word1 and word 2 may occur within the same phrase.
- word1 and word2 may be separated by an intonational phrase boundary, i.e., each word belongs to a different phrase.
- we get pairs of sentences like (5):

- (5) Roma è una **città santa**. “Rome is a holy city”
Se conosci la **città, santa** non è. “If you know the city, it’s not holy”

2.1.3 Segment quality

- word1 always ends in vowel (/i/ or /a/).
- word2 begins with a consonant (/s/ or /p/), or with vowel (/i/ or /a/).
- we get sentences like (6):

² The target segments are underlined in the examples.

- (6) Fu un **giovedì acido**. “It was a hard Thursday”
 Fu un **giovedì sobrio**. “It was a sober Thursday”

2.1.4 Summary of stimuli

- Same syntactic environment: all phrases are formed by noun and adjective.
- Same segmental environment: relevant segments are preceded or followed by same type of segment.

Table I Summary of stimuli (see Appendix 1 for sentences representing the environments)

| Phrase internally (#) | | | | Phrase juncture (##) | | | |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Final stress (´) | | Non-final stress | | Final stress (´) | | Non-final stress | |
| V _{w1} V _{w2} | V _{w1} C _{w2} | V _{w1} V _{w2} | V _{w1} C _{w2} | V _{w1} V _{w2} | V _{w1} C _{w2} | V _{w1} V _{w2} | V _{w1} C _{w2} |
| à # i | à # s/p | a # i | a # s/p | à ## i | à ## s/p | a ## i | a ## s/p |
| ì # a | ì # s/p | i # a | i # s/p | ì ## a | ì ## s/p | i ## a | i ## s/p |

2.2 Speakers and Recording

- Five native Italian speakers were recorded – One speaker was discarded:
 - fifth speaker from Gorizia (northern Italy) was recorded. A perception analysis showed that this speaker behaved differently. She lacked Raddoppiamento and geminate consonants altogether. This is a characteristic of northern varieties of Italian (Nespor 1978, Saltarelli 2003).
- Four speakers analyzed: Tuscan origin, young college adults.
- Recorded under controlled conditions.
- Written instructions in Italian asking speakers to read in colloquial style.

2.3. Analysis

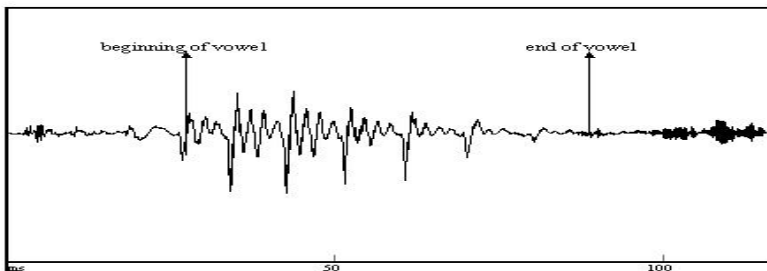
- After digitization, waveforms and spectrograms were obtained to measure the relevant segments.

- The following criteria were used:

➤ *for VI C sequences*

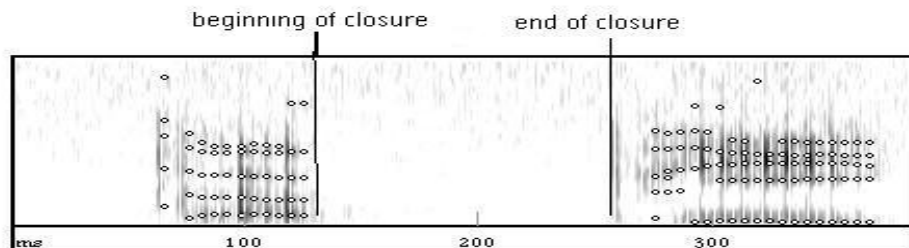
- duration of vowel: from first glottal pulse to the last full vocal pulse.
See Fig. 1.

Fig. 1 Duration of unstressed /a/



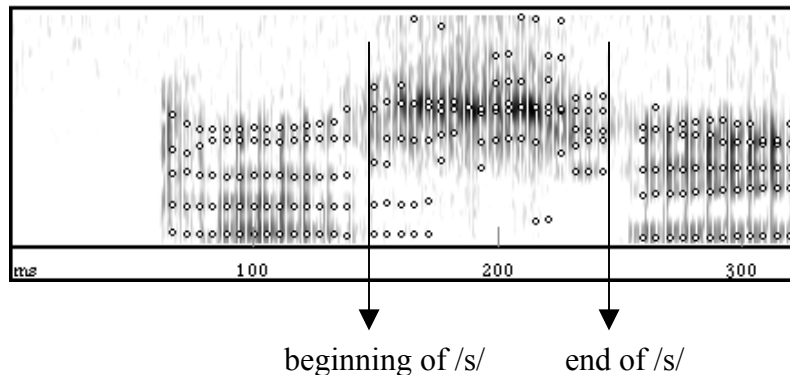
- duration of stop consonant: from the end of preceding vowel to release of closure. See Fig. 2.

Fig. 2 Spectrogram for /p/



- duration of fricative: from beginning of period of high energy above vowel formants the end of this period. See Fig. 3.

Fig. 3 Spectrogram for /s/



➤ for V1 V2 sequences

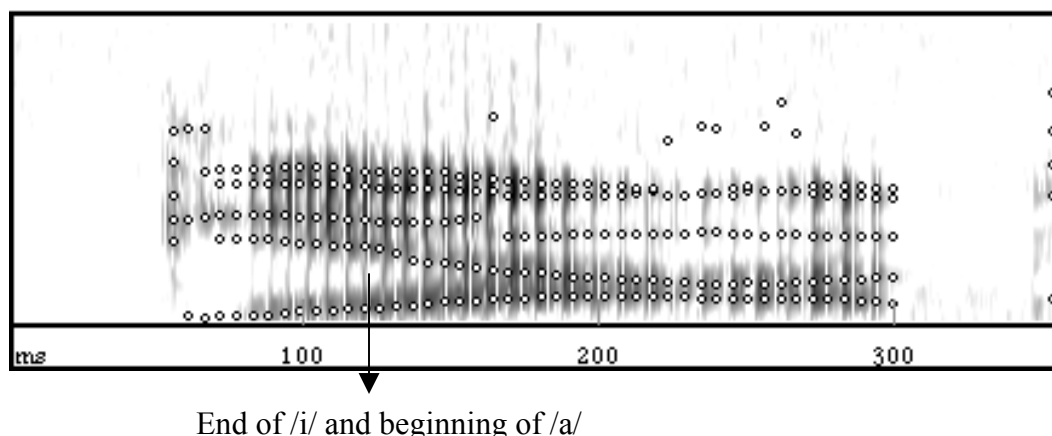
- duration of V1 and V2 when pause was present: from beginning of first glottal pulse to the end of last pulse.
- duration of V1 and V2 when pause was not present:
 - Beginning of V1: first glottal pulse.
 - End of V2: end of last glottal pulse.
 - End of V1 and beginning of V2:

-Waveform and spectrogram were synchronously used:

➤ In waveform, diagnostic was change in shape corresponding to transition from one vowel to another, i.e., low to high energy for /a i/ and high to low energy for /i a/.

➤ In spectrogram, diagnostic was amount of F1 change in formant transition. LPC formant tracking of sequence allowed us to establish the end of V1 where biggest fall, /i a/, or rise, /a i/, in value of F1 took place. That point was considered beginning of V2. See Fig. 4

Fig. 4 Spectrogram for sequence /i a/



3. Results

- Three-factor full interaction ANOVAs for the duration of the three relevant segments (V_{w1}, C_{w2}, V_{w2})³ and for each speaker were carried out.
- To test the difference between the postboundary consonant after a stressed vowel and after an unstressed vowel, a planned comparison test was performed.

3.1 Duration of initial consonant C in word2

- Three-factor ANOVA for each speaker: duration of initial C as dependent variable, and stress, boundary and final vowel identity as independent variables:
 - Significant effect of stress for all subjects: initial C is longer after stress.
 - Significant duration difference for postboundary consonant depending on stress of preceding vowel for two speakers.

Table II. Duration of initial consonant in word2 and factors.

s= stressed final vowel, **u**=unstressed final vowel

b=intonational boundary, **nb**=no intonational boundary

✓ = statistically significant difference ($p \leq 0.05$), **no**=no stat. significant difference

| | Stress effect | Boundary effect | V1identity Effect | Stress & Boundary interaction | Boundary & stress vs. Boundary & no-stress difference |
|-----------|---------------|-----------------|-------------------|-------------------------------|---|
| Speaker A | ✓ s>u | ✓ b>nb | No | ✓ snb>sb | no |
| Speaker C | ✓ s>u | ✓ nb>b | ✓ i>a | ✓ snb>sb | ✓ |
| Speaker P | ✓ s>u | ✓ nb>b | ✓ i>a | ✓ snb>sb | ✓ |
| Speaker T | ✓ s>u | ✓ nb>b | No | ✓ snb>sb | no |

³ The duration of stops was not considered since it was impossible to distinguish between stop closure and a potential pause. Only fricatives were included in the three-factor ANOVAs. However, the stop data was included in an additional two-factor ANOVA (stress and segment identity). The results of the latter further evidence the general findings.

3.2 Duration of initial vowel in word2

• Three-way factor ANOVA for each speaker: duration of initial vowel V2 as dependent variable, and stress, boundary and identity of initial vowel as independent variables:

- Stress does not have a significant effect on V2 duration for three of the speakers.
- V2 is longer when no boundary is present: phrase initial shortening.

Table III. Duration of initial vowel in word2 and factors

| | Stress effect | Boundary effect | V2 identity effect | Stress & Boundary interaction |
|-----------|---------------|-----------------|--------------------|-------------------------------|
| Speaker A | no | ✓ n>b | ✓ a>i | no |
| Speaker C | ✓ u>s | ✓ n>b | ✓ a>i | no |
| Speaker P | no | ✓ n>b | ✓ a>i | no |
| Speaker T | no | ✓ n>b | ✓ a>i | no |

3.3 Duration of final vowel in word1

• Three-way factor ANOVA for each speaker: duration of final vowel V1 in word1 as dependent variable, and stress, boundary and identity of following segments as independent variables:

- V1 is affected by stress: final vowel is longer when stressed.
- V1 is longer before a boundary: phrase final lengthening.

Table IV. Duration of final vowel in word1 and factors

| | Stress effect | Boundary effect | Following segment effect | Stress & Boundary interaction |
|-----------|---------------|-----------------|--------------------------|-------------------------------|
| Speaker A | ✓ s>u | ✓ b>n | ✓ i>a>f | ✓ sb>snb |
| Speaker C | ✓ s>u | ✓ b>n | no | ✓ sb>snb |
| Speaker P | ✓ s>u | ✓ b>n | ✓ i>f>a | ✓ sb>snb |
| Speaker T | ✓ s>u | ✓ b>n | no | ✓ sb>snb |

3.4 Pause effects

3.4.1 Establishing pause duration

- Potential pause in environments where there is a boundary.
- There are different degrees of periods of silence.
- Duez (1981): periods of silence, no periodic or aperiodic noise, of 200 ms and over constitute a pause.
- Only speaker C has a significant number of tokens with a pause.

3.4.2 Results

- Two-factor ANOVA for speaker C: duration of initial fricative in word2 as dependent variable, and stress and pause as independent variables.
- Presence or absence of pause does not have a significant effect on segment duration.

4. Discussion

4.1 Hypothesis 1

Initial consonant in word2 lengthens after a stressed vowel.

- Results support our hypothesis and evidence Raddoppiamento: initial consonants are longer after stressed vowels.

- Consider the degree of lengthening with respect to previous studies that analyze Raddoppiamento as gemination (Borrelli 2000, Chierchia 1983-6)

Table V Duration (ms) of initial fricative in word2 (no boundary).

| | After stressed vowel | After unstressed vowel | Percentage of lengthening |
|-----------|----------------------|------------------------|---------------------------|
| Speaker A | 139 | 113 | 23% |
| Speaker C | 175 | 109 | 60% |
| Speaker P | 159 | 103 | 55% |
| Speaker T | 175 | 115 | 52% |

- Table V can be compared with the results from an independent study by Farnetani and Kori (1986) for single and geminate /s/ (Table VI): the percentage of lengthening for Raddoppiamento is smaller than the lengthening for geminates.

Table VI. Duration (ms) of fricative single and geminate consonant from Farnetani and Kori (1986)

| | Geminate C | Single C | Percentage of Lengthening |
|-----------|------------|----------|---------------------------|
| Speaker 1 | 221 | 127 | 74% |
| Speaker 2 | 255 | 87 | 193% |
| Speaker 3 | 271 | 117 | 131% |

- This suggests that Raddoppiamento does not involve the formation of geminates.
- **Follow-up study** measured the duration of medial single and geminate /s/:

- stimuli were similar to those used in the previous experiment (see Appendix 2)

(7) Le nostre sono **basi** deboli “Ours are weak bases”

- noun carrying the relevant segment was a bisyllabic word with initial stress; the target segment appears after a stressed vowel.
- two speakers from the previous experiment were recorded under the same conditions.

- Compare Table V with the percentage of lengthening of geminates in Table VII.

Table VII. Geminate/singleton duration (ms).

| | Geminate C | Single C | Percentage |
|-----------|------------|----------|------------|
| Speaker A | 123 | 41 | 200% |
| Speaker T | 143 | 38 | 276% |

4.2 Hypothesis 2

Initial consonant in word2 does not lengthen after a boundary

- Our results refute this hypothesis: difference in length of postboundary consonant depending on stress of preceding vowel was significant for two speakers.
- Presence of a boundary did not block lengthening from taking place.
- Comparing Table V and VIII, the degree of lengthening is greater when no boundary is present.

Table VIII Duration (ms) of postboundary consonant.

| | After stressed V | After unstressed V | Percentage of lengthening |
|-----------|------------------|--------------------|---------------------------|
| Speaker C | 130 | 121 | 8% |
| Speaker P | 123 | 114 | 8% |

- Similarly, presence of pause does not categorically prevent Raddoppiamento from applying. However, the degree of lengthening is smaller after a pause.

Table IX Duration (ms) of initial consonant and effect of pause (speaker C)

| | After stressed V | After unstressed V | Percentage of Lengthening |
|----------|------------------|--------------------|---------------------------|
| Pause | 130 | 112 | 16% |
| No pause | 156 | 115 | 35% |

4.3 Hypothesis 3

Initial vowel in word2 lengthens after stressed vowel

- Results refute this hypothesis: stress does not affect this vowel.
- Initial vowel does not lengthen in Raddoppiamento environments.

4.4 Hypothesis 4

Initial vowel in word2 does not lengthen after boundary.

- Results support this hypothesis: this vowel is shorter after a boundary.
- However, this hypothesis meant to make reference to Raddoppiamento lengthening so in this case, the hypothesis is refuted because stress does not have an effect on the vowel.

4.5 Hypothesis 5

Final vowel in word1 does not lengthen when stressed.

- Results refute this hypothesis: final vowel is longer when stressed.
- Consider the degree of lengthening of this final vowel in Table X: this degree is greater than in the cases of Raddoppiamento (compare with Table V).

Table X Duration (ms.) of final vowel without following boundary.

| | Stressed | Unstressed | Percentage of lengthening |
|-----------|----------|------------|---------------------------|
| Speaker A | 77 | 53 | 44% |
| Speaker C | 102 | 63 | 62% |
| Speaker P | 91 | 49 | 85% |
| Speaker T | 83 | 42 | 96% |

5. Conclusion

- Findings:
 - only consonants are subject to Raddoppiamento.
 - presence of intonational phrase boundary does not block Raddoppiamento.
 - final stressed vowel lengthens, compared to its unstressed counterpart.

- Looking at boundary effects and degrees of lengthening in different environment: Raddoppiamento is viewed as a gradient phenomenon.

REFERENCES

- Borrelli, D.A. (2000). *Raddoppiamento Sintattico in Italian: a synchronic and diachronic cross-dialectal study*. Ph.D. dissertation. Cornell University.
- Chierchia, G. 1983-86. Length, syllabification and the phonological cycle in Italian. *Journal of Italian Linguistics*.
- Duez. 1981. Pauses silencieuses et pauses non silencieuses dans trios types de messages oraux. *Travaux de l'Institut de Phonetique d'Aix* 8: 85-114
- Farnetani, E. and S. Kori. 1986. Effects of syllable and word structure on segmental durations in spoken Italian. In *Speech Communication* 5: 17-34.
- Napoli, D.J. and M. Nespors. 1979. The syntax of word initial gemination in Italian. *Language* 55: 812-843.
- Nespors, M. (1978). *Some syntactic structures of Italian and their relationship to the phenomenon of Raddoppiamento Sintattico*. Ph.D. Dissertation. University of North Carolina.
- Nespors, M. and Vogel, I. (1979). Clash avoidance in Italian. *Language*, 10, 467-48.
- Nespors, M. and I. Vogel. 1986. *Prosodic Phonology*. Dordrecht: Foris.
- Vogel, I. 1978. Raddoppiamento as a resyllabification rule. *Journal of Italian Linguistics* 3, 15-28.
- Saltarelli, M. 2003. A constraint interaction theory of Italian Raddoppiamento: Quantity restrictions and enhancement. Ms. University of Southern California.

Appendix 1

1. La nostra è una facoltà ibrida.
“Ours is a hybrid faculty”
2. Fu un giovedì acido.
“It was a hard Thursday”
3. Roma è una città santa.
“Rome is a holy city”
4. Siena è una città piccola.
“Siena is a small city”
5. Fu un giovedì sobrio.
“It was a sober Thursday”
6. È stato un giovedì povero.
“It’s been a miserable Thursday”
7. È una pianta ibrida.
“It is a hybrid plant”
8. Sono studenti abili.
“They are handy students”
9. Ha comprato frutta secca.
“He’s bought dry fruit”
10. Siamo passati per la porta piccola.
“We’ve passed through the small door”
11. Sono studenti sobri.
“They are sober students”
12. Siamo studenti poveri.
“We are poor students”

13. Se conosci la facoltà, ibrida non è.
“If you know the faculty, it is not hybrid”
14. Quando lo mangiammo giovedì, acido non era.
“When we ate it on Thursday, it was not sour”
15. Se conosci la città, santa non è.
“If you know the city, it is not holy”
16. Se conosci la città, piccola non è.
“If you know the city, it is not small”
17. Quando lo vedemmo giovedì, sobrio non sembrava.
“When we saw him on Thursday, he did not look sober”
18. Quando si presentò l’attrice giovedì, piccola non era davvero.
“When the actress introduced herself on Thursday, she was not small at all”
19. Quando studiamo quella pianta, ibrida non era.
“When we studied that plant, it was not hybrid”
20. Quando abbiamo conosciuto gli studenti, abili non erano davvero.
“When we met the students, they were not handy at all”
21. Quando mangiammo la frutta, secca non era.
“When we ate the fruit, it was not dry”
22. Quando siamo passati per quella porta, piccola non era.

- “When we passed through that door, it was not small”
23. Quando abbiamo conosciuto gli studenti, sobri non sembravano.
“When we met the students, they did not look sober”
24. Quando abbiamo conosciuto gli studenti, poveri non erano davvero.
“When we met the students, they were not poor at all”

APPENDIX 2

Stimuli used in experiment analyzing single/geminate consonants duration.

- 1- Le nostre sono basi deboli.
“Ours are weak bases”
- 2- Cammina a passi lunghi.
“He walks with long steps”
- 3- Abbiamo ricevuto la carta Visa nuova.
“We have received the new Visa card”
- 4- Siamo finiti in una rissa furiosa.
“We ended in a furious fight”