



3-23-2009

An Acoustic Analysis of Intrusive Vowels in Guatemalan Spanish /rC/ Clusters

Benjamin Schmeiser
Illinois State University

An Acoustic Analysis of Intrusive Vowels in Guatemalan Spanish /rC/ Clusters

Abstract

Quilis's (1970, 1993) instrumental work on the acoustic analysis of intrusive vowels (henceforth, IVs) in Spanish has greatly enhanced our understanding of these short, vowel-like fragments found between a Spanish tap, /r/, and its adjacent consonant. His work on IV formant structure in /Cr/ clusters suggests that IVs exhibit the same properties of the nuclear vowel. Quite surprisingly, however, no known study exists that treats the IV formant structure in heterosyllabic /rC/ clusters. The current study fills this gap in the analysis by examining the acoustic properties of IVs in Spanish /rC/ clusters and comparing them to Quilis's (1970, 1993) findings on their /Cr/ cluster counterparts. By doing so, the study greatly contributes to linguistic research by offering empirical data from a variety of Spanish on a topic previously unattested and advances our understanding of IV formant structure. With regards to experimental design, I analyzed the acoustic properties of the IV from a corpus that includes ten subjects from Guatemala City, Guatemala; 197 /rC/ clusters were analyzed spectrographically using Praat and categorized by their flanking vowels (e.g. a_a). Subjects were recorded at a sample rate of 22,050 Hz and sample size of 16-bit. Preliminary data results suggest that the acoustic properties of IVs in /rC/ clusters are unlike those of their /Cr/ counterparts in that they are not linked to a particular nuclear vowel. The formant structure is typically that of a mid vowel, with an average F1 value of 425 and an average F2 value of 1480, regardless of the flanking vowels' quality.

In theoretical, Articulatory Phonological (Browman and Goldstein, 1989 et seq.) terms, Gafos (2002) notes that both consonants in the tautosyllabic onset cluster have a timing relationship with the underlying (nuclear) vowel. However, Gafos (2002) also mentions that whereas a consonant in coda position has a timing relationship with its nuclear vowel, the following (heterosyllabic) consonant has a timing relationship the nuclear vowel of the following syllable. The current study's findings are novel in that they suggest the IV in a /rC/ cluster has no apparent timing relationship with either of the neighboring nuclear vowels, as evidenced by its neutral formant structure. Thus, the findings corroborate Gafos's (2002) notions with empirical evidence and shed new light on his view of the syllable.

An Acoustic Analysis of Intrusive Vowels in Guatemalan Spanish /rC/ Clusters

Benjamin Schmeiser*

1 Introduction

Unlike vowel epenthesis, vowel intrusion is not part of the syllabic make-up of the word. It is, in Quilis's (1970) words, a "perfect glottal sound" ("*un perfecto sonido glótico*") (99). It is quite surprising, then, that we know very little about this "perfect glottal sound" in terms of its formant structure and the effects that flanking vowels have on it. The current study nicely complements Quilis's (1970, 1993) work on Spanish /Cr/ clusters by investigating their counterpart /rC/ clusters and thus enhances our understanding of a topic that is of great interest currently to Spanish linguists by treating a particular environment that has previously been largely ignored.

Spanish exhibits an intrusive vowel (henceforth, IV) between an alveolar tap and an adjacent obstruent¹ (Lenz, 1892; Araujo, 1894), as in:

- | | |
|---|--|
| (1) /Cr/ clusters: | /rC/ clusters: |
| a. <i>pronto</i> [p ^ɹ r] 'soon' | e. <i>enorme</i> [r ^ɹ m] 'enormous' |
| b. <i>otro</i> [t ^ɹ r] 'other' | f. <i>parte</i> [r ^ɹ t] 'part' |
| c. <i>fresco</i> [f ^ɹ r] 'cool, fresh' | g. <i>porque</i> [r ^ɹ k] 'because' |
| d. <i>negro</i> [ɲ ^ɹ r] 'black' | h. <i>cerdos</i> [r ^ɹ d] 'pigs' |

In Spanish, /Cr/ clusters are tautosyllabic and /rC/ are *almost* always heterosyllabic in that there are six words in Spanish which evidence an /rC/ cluster as a tautosyllabic, complex coda cluster (e.g. *perspectiva* [pers.pɛk.tí.βa] 'perspective'), which are not treated in the current discussion. The current study limits itself solely to the heterosyllabic environment (seen in (1e-h)), which exhibits a longer IV² mean duration than its tautosyllabic counterpart (Schmeiser, 2006). Throughout the paper, I follow previous phonetic representation of the IV in Spanish (Lenz, 1892; Malmberg, 1965; Bradley, 2004, 2005, 2007; Bradley and Schmeiser, 2003; Kilpatrick, Kirby, and McGee, 2006; Schmeiser, 2006, 2007a,b) by denoting the IV as the superscripted schwa, [ɹ].

In the last decade, Spanish linguists³ (Ramírez, 2002, 2006; Bradley and Schmeiser, 2003; Colantoni and Steele, 2005, 2007; Kilpatrick, Kirby, and McGee, 2006; Bradley, 2007; Schmeiser, 2006, 2007b) have sought to ascertain what factors condition both intrusive vowel presence and duration. Though we now understand a considerable amount regarding the prosodic and segmental factors that condition IV duration, very few studies (Quilis, 1970, 1993) have offered an acoustic analysis of IVs in /Cr/ clusters and there have been no known studies of IVs in /rC/ clusters.

Quilis's (1970) work on /Cr/ clusters first suggests that IVs exhibit the same properties of the nuclear vowel; that is, the formant structure of the IV is proportional to the tautosyllabic, nucleic vowel. In his 1993 study, he offers the following figure to exemplify this:

*I wish to thank the members of the PLC 32 audience for their insightful comments and questions which have been greatly beneficial to the study.

¹To my knowledge, Malmberg (1965) is the only study that suggests that an IV can occur in Spanish when the tap is not present (e.g. *resbalar* [res^ɹ.βa.lár] 'to slide' (44). Also, Araujo (1894) and Gili Gaya (1921) note another environment, namely after an alveolar tap in utterance final position (e.g. *voy a escribir* [r^ɹ] 'I am going to write').

²I utilize the term "intrusive vowel" in the current study. Observe that it is also referred to in the literature as "the epenthetic," "epenthetic vowel," "excrement vowel," "schwa insertion," "excrement schwa," or "svarabhakti vowel."

³For studies outside of Spanish, see Davidson (2003) and Hall (2003).

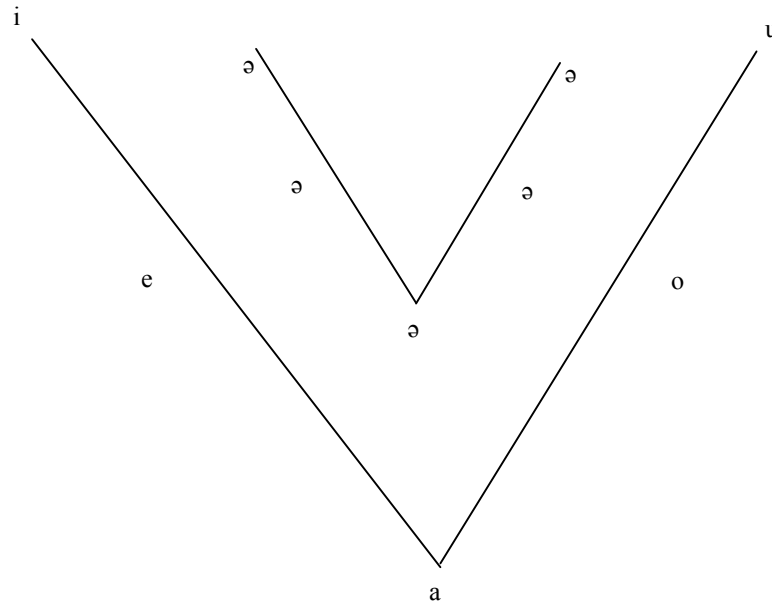


Figure 1: The 5 Spanish canonical nuclear vowels and their corresponding IVs.

As Figure 1 illustrates, Spanish has five vowels: /a/, /e/, /i/, /o/ and /u/; IVs are proportional to their corresponding nucleic vowel. The following table shows the average values (Hz) of both the IV and the vowel:

[^ə]		Vowel		
F1	F2	F1	F2	
348	1745	318	2360	i
388	1645	414	2011	e
469	1482	642	1486	a
396	1213	445	1114	o
340	1111	343	988	u

Table 1: Formant structure averages (Hz) for IV and corresponding vowel (adapted from Quilis 1993:340).

Since the Quilis (1970, 1993) studies, however, no known study has researched IV formant structure in the /rC/ environment. Given that /rC/ clusters are heterosyllabic, it is logical to assume that the IV might not pattern in the same manner as in its /Cr/ counterpart; that is, the IV in a heterosyllabic context might not have the formant structure of the nuclear vowel of the syllable in which it resides given that the IV is located at a syllable boundary (see Figure 5 below). For example, diachronic evidence supports Quilis's (1970, 1993) notion that the IV copies the formant structure of the nuclear vowel, prompting his hypothesis that IVs that realize into phonological full vowels over time are always copied from the nuclear vowel (1970:102), as in (2a). Notice, however, that we observe no evidence of this diachronic phenomenon in Spanish for the heterosyllabic, /rC/ clusters, in which the IV never achieves full vowel status, as in (2b):

- (2) a. tigre > tiguere 'tiger'
 b. parte > *parate 'parte'

Given this difference, it is the central goal of the current study to examine the acoustic properties of IVs in Spanish /rC/ to determine the effects that the flanking vowels might have on their formant structure. In doing so, I am able to then compare the results to Quilis's (1970, 1993) findings on /Cr/ clusters. Hence, the study greatly contributes to linguistic research by offering empirical data on a topic previously unattested and advances our understanding of IV formant structure. Moreover, it uses a data collection from a variety of Spanish that is under-studied in phonetic and phonological research. Finally, the results provide implications for current theoretical research.

The rest of the paper is organized as follows: §2 offers the experimental design, §3 details the results of the study, including a discussion of the findings, and §4 concludes. An appendix of the passage read (with English translation) follows.

2 Experimental Design

2.1 Subjects

The current study consists of ten subjects, five male and five female. All subjects were native speakers of Guatemalan Spanish, spoke Spanish at home, and were either from Guatemala City, Guatemala or had spent a minimum of thirty years living there. Finally, all of the subjects' parents were native speakers of Guatemalan Spanish as well. Ages ranged from twenty-one to fifty-four. Social status and education varied. The following table includes the gender and age for each subject:

Subject	Gender	Age	Subject	Gender	Age
1	female	54	6	male	44
2	female	21	7	male	25
3	female	35	8	male	30
4	male	34	9	female	38
5	male	25	10	female	21

Table 2: Subject number, gender, and age.

2.2 Data Collection

Each subject read a consent form in which s/he was told that the experiment was for linguistic research of Guatemalan Spanish. Each subject then read from a passage of 421 words in length (see Appendices A and B). Each passage contained twenty-three /rC/ clusters and thirty-three /Cr/ clusters (not treated in the current study). I note that not all clusters evidence an IV in Spanish. Schmeiser (2006) found that 84.21% of /rC/ clusters in the five varieties tested exhibited an IV (50). The subjects were recorded using a Lenovo USB/Analog headset by Sennheiser, with a sample rate of 22,050 Hz and sample size of 16-bit. The subject read at his/her natural speed and was recorded in a quiet room with all electrical devices unplugged. Upon completion, the subject was given a modest honorarium. Total time with each subject was generally around thirty minutes.

Subject files were originally recorded using the Winamp software program. All recordings were conducted within a two-week period in January of 2008 in Guatemala City, Guatemala. Spectrographic analyses, waveforms, and formant structure analyses were taken using the Praat software program (version 4.6.12). What follows is a spectrogram which illustrates a canonical IV in a /rC/ cluster. In the below figure, the arrows draw attention to the [por³] portion of the word, *importante* 'important.' In this portion, the voiceless plosive stop is followed by the mid-back vowel, the alveolar tap, and finally a canonical (e.g. easily perceptible) IV:

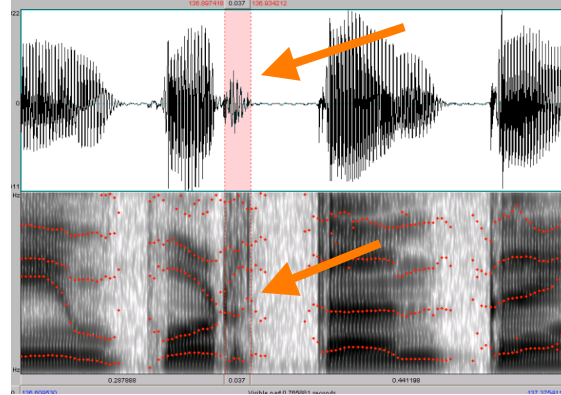


Figure 2: Spectrogram of a canonical IV in a Spanish /rC/ cluster in *importante* [r³t] ‘important.’

3 Data Analysis

3.1 Results

For the current study, 197 tokens were collected, with an overall average F1 value (Hz) of 492 and an overall F2 value (Hz) of 1559. The tokens were first categorized into ten categories, based on flanking vowels, to extrapolate any possible effects from both flanking vowels, as seen in the following table:

Environment	Average F1 value (Hz)	Average F2 value (Hz)
a a	499	1661
o e	495	1542
o a	516	1458
ue o	509	1583
e ua	429	1712
o i	529	1586
e e	563	1676
e o	460	1464
a e	469	1596
ue a	461	1518

Table 3: Average IV F1 and F2 values (Hz) between flanking vowels.

No real trend emerged in this analysis in that average F1 and F2 values do not evidence any striking tendencies. Thus, considering Quilis’s (1970, 1993) findings for the heterosyllabic environment, the tokens were also analyzed in terms of their nucleic vowel (i.e. the left flanking vowel). Observe that no tokens were available in which the nucleic vowel was /i/; this shortcoming was merely a result of the passage selected and will be addressed in future research.

Environment	Average F1 value (Hz)	Average F2 value (Hz)
i	n/a	n/a
u	485	1551
e	484	1464
o	507	1586
a	484	1629

Table 4: Average IV F1 and F2 values (Hz) as categorized by the nucleic vowel.

In Table 4, one observes the average F1 and F2 values (Hz) for the IV when following the nucleic vowel listed in the table. For example, in the case of *parte* [ar^ə] ‘part,’ this table considers the effect the formant structure of the nucleic vowel (/a/) might have on the IV. Given that vowel height is inversely correlated to F1, we might suspect that an IV after a high vowel (e.g. /u/) would result in a lower F1 than the low vowel, /a/, but that in fact is not what we observe, with the average F1 value after /u/ actually higher (485 Hz) than it is after /a/ (484 Hz). With regard to F2, backness is inversely correlated to the F2 value and thus we might expect a higher average F2 value for an IV if there is a correlation between the two vowels. We do not, however, observe this trend; in fact, we notice that the highest average F2 value for the IV is after /a/, and not after the back vowel /u/.

Finally, the data were also analyzed in terms of the following vowel to determine if the right flanking vowel had an effect on IV formant structure. Given that the right flanking vowel is in the neighboring syllable, the vowel’s effects on IV formant structure would seem unlikely. That said, I include it in the current analysis because it is the first study to consider the vocalic influence on IV formant structure in Spanish and I wanted to test both flanking vowels. The following table includes the results:

Environment	Average F1 value (Hz)	Average F2 value (Hz)
i	509	1506
u	429	1712
e	509	1604
o	484	1523
a	492	1546

Table 5: Average IV F1 and F2 values (Hz) as categorized by following vowel.

As in the previous tables (Tables 3 and 4), again we observe no real trend in the formant structure of IVs in Spanish. With regard to F1, we would expect a trend of higher F1 values from high vowels to low vowels; no such trend emerges in the current study, as evidenced in the data in Table 5. In terms of F2, we again see no trend of higher average F2 values from back to front, with the highest average F2 value actually occurring after the back vowel /u/.

3.2 Discussion

In short, in the above tables we observe *relative* stability in that the environment does not seem to *greatly* affect IV formant structure. The data results in the current study evidenced average F1 values between 400 and 600 and average F2 values between 1450 and 1750, regardless of the flanking vowels, which would place an average IV somewhere between /e/ and /a/. This is in direct opposition to the tautosyllabic, /Cr/ context in Quilis’s (1970, 1993) work in which the IV formant structure is affected by the tautosyllabic vowel. These findings are best described using a gestural approach, along with Gafos’s (2002) notion of a syllable.

In terms of a gestural approach, Articulatory Phonology (Browman and Goldstein, 1989, et seq.) is optimal for the current study in that it uses as its basic unit the gesture, which is a dynamically-defined articulatory movement that produces a constriction in the vocal tract; gestures are temporally coordinated with respect to each other and may exhibit varying degrees of overlap. Central to the current study is that consonantal articulations are superimposed on vocalic gestures (Gafos, 1999). In the following figure, we observe three consonants (C¹, C², and C³) superimposed on a vocalic gesture. C¹ and C² represent a tautosyllabic complex onset cluster, whereas C³ and C⁴ represent a heterosyllabic C-C cluster in which C³ is in coda position and C⁴ is in onset position of the following syllable:

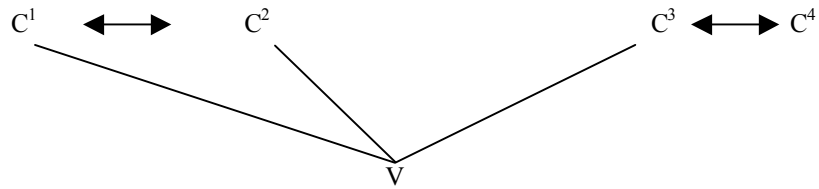


Figure 3: Gestural phasing relationships within a syllable (adapted from Gafos 2002:316).

In the case of tautosyllabic /Cr/ clusters, both C¹ and C² have a more stable timing relationship with the nucleic vowel, whereas the following consonant (C³) has a weaker timing relationship with the nucleic vowel, called an “anti-phase” in Goldstein, Byrd, and Saltzman’s (2006) terms. This is illustrated in the following gestural representations:

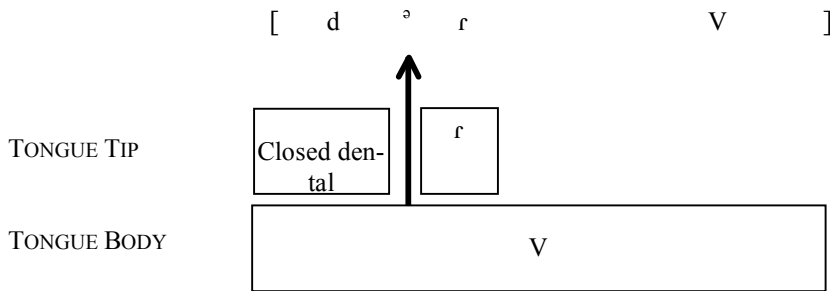


Figure 4: A gestural representation for [d^ər].

Observe in Figure 4 that in the tautosyllabic /Cr/ context, both the /d/ and the /r/ have a timing relationship with each other and with the same nucleic vowel. The IV that is perceived by the listener in the middle of the cluster is actually the underlying nucleic vowel. By contrast, the consonant cluster in the /rC/ context exhibits a rather different timing relationship, illustrated in Figure 5:

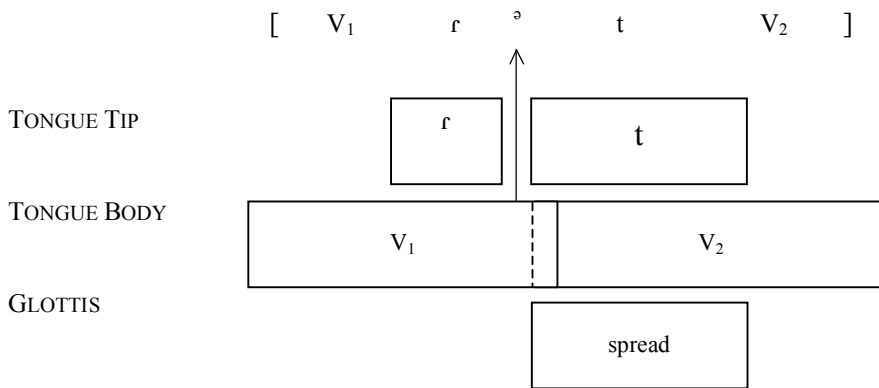


Figure 5: A gestural representation of [Vr^ə.tV].

Note in Figure 5 that, unlike in the tautosyllabic context, the consonant cluster is now separated by a syllable boundary. The IV in this case is in the “anti-phase” position of V₁, or, said another way, lies between two heterosyllabic consonants, which is a less stable environment (Byrd, 1996a,b; Krakow, 1999; Byrd et al, 2000; Browman and Goldstein, 2001; Byrd and Saltzman, 2003; Nam and Saltzman, 2003; Goldstein, Byrd, and Saltzman, 2006). In previous work regarding consonantal effects on IV duration, Schmeiser (2007b) finds that segmental factors play a lesser role in the heterosyllabic context. Just as with consonantal influence on the IV, the prosodic boundary also seems to prohibit flanking vowel formant structure from affecting IV formant structure in the heterosyllabic context.

4 Conclusions

The recent studies that treat IV occurrence and duration have greatly increased our understanding of intrusive vowels in Spanish. The body of work has concentrated on tautosyllabic /Cr/ clusters, including Quilis's (1970, 1993) important studies on the acoustic qualities of the IV. The current study adds to the growing number of studies on IVs in Spanish by treating the acoustic qualities of the IV in the heterosyllabic /rC/ context.

Results suggest that an IV in the heterosyllabic context differs from its tautosyllabic counterpart in that the IV is unaffected by either flanking vowel's formant structure. Using a gestural approach and Gafos's (2002) notion of the syllable, I posit that this difference is due to the IV's position in the syllable. That is, when an IV is at a prosodic boundary, it seems to function as a transitional element, with its formant structure unaffected by the two flanking vowels. As illustrated in this study, historical examples support this notion in that intrusive vowels have taken on phonological full-vowel status in /Cr/ clusters, but no known example exists in the case of /rC/ clusters.

Provided that this is a preliminary study, I controlled only for the flanking vowels. One possible avenue for future research would be to consider consonantal effects on IV formant structure; I refer the reader to Ramírez (2006) for further reading on this topic as it pertains to /Cr/ clusters and their perceptibility. Additionally, the data are from one variety of Spanish; future research might consider other varieties of Spanish and even compare them to ascertain any variation between them. As the purpose of this study was to investigate IVs in Spanish, I did not investigate other languages. Given the lack of cross-linguistic analysis, future researchers should test flanking vowel effects on IVs in other languages. Though previous accounts (Colantoni and Steele, 2005; Schmeiser, 2006) of IV duration have noted that gender is not significant, future studies might include gender, along with age, to investigate their significance on IV formant structure. Finally, I note that many examples which included an IV before a voiceless dental stop were quite difficult to analyze. Future research might consider this a separate category within the study.

Appendix A: Reading Passage (Spanish)

Quando yo era niño, iba todos los años a pasar uno de los meses de vacaciones a casa de mi tío. La hacienda y sus dependencias abarcaban un terreno muy extenso. Estaban rodeadas de un enorme patio. Solía ayudar a mi tío y a sus empleados cuando podía, aunque probablemente no les ayudaba tanto como yo creía. En las cuerdas tenía mi tío seis o siete caballos y algunas yeguas. Pero ahora, porque vive todavía, los ha sustituido por tractores y por una camioneta. En los establos tenía magníficos bueyes. Recuerdo como si fuera ayer cuando los vi por primera vez. También había vacas con sus terneros, así como cabras, ovejas y corderos. Menos pintorescos, pero de igual utilidad, eran los cerdos que vivían en sus pocilgas, y los gallos y las gallinas que tenían lo que a mí me parecía entonces un inmenso gallinero.

Para un niño que pasaba once meses del año en una gran población, constituían una novedad los pavos, los patos y los gansos que en otras partes no encontraba sino muertos y preparados para la mesa en la cocina. Uno de los encantos de aquellas visitas era la abundancia de frutas que comía yo en gran cantidad. Generalmente, las fresas y las frambuesas habían pasado ya, pero nos quedaban grosellas y cerezas. Y los manzanos, perales y ciruelos estaban cargados de fruta madura, hermosa y succulenta. ¿Cuáles son las diferentes partes de la hacienda? La casa, el patio, las dependencias y los campos que rodean la casa. ¿De qué constan las dependencias? Constan de las cuerdas, los establos, los rediles, las pocilgas y los gallineros. ¿Cuál es, según Ud., el más útil de los animales domésticos? Yo creo que la vaca, no sólo porque da leche, sino porque la leche se transforma en mantequilla y en queso. Y además, la carne de vaca es una parte muy importante en nuestras comidas diarias.

¿No tenía su tío de Ud. abejas? No, Señor. Cuando se instaló en su hacienda hace treinta años, compró una gran cantidad de abejas. Pero la miel le daba tan poco que las vendió. ¿Tenía grandes huertas? No, nada más que una que estaba detrás de la casa. Pero era muy productiva, y daba cada año gran cantidad de frutas y legumbres. Pruebe Ud. una manzana. O, ¿prefiere Ud. ciruelas? Aquí

las hay verdes si le gustan más que las maduras. Están muy dulces, gracias. Voy a tomar una de estas manzanas. Las peras y las manzanas son las frutas que más me gustan.

Appendix B: Reading Passage (English)

When I was a boy, every year I used to spend one month of my vacation at my uncle's house. The ranch and its premises covered a very extensive territory. They were surrounded by an enormous patio. I used to help my uncle and his employees whenever I could, though I probably did not help them as much as I wanted. In the stables, my uncle had six or seven horses and some mares. But now, because he is still alive, he has replaced them with tractors and a van. In the stables, he had magnificent oxen. I remember as if it were yesterday when I saw them for the first time. There were also cows with their calves, and also goats, sheep and lambs. Less picturesque, but equally useful, were the pigs that lived in their pigsties, and the roosters and hens that had what seemed to me at the time a huge hen run.

For a boy who spent 11 months out of the year in a highly-populated area, it was a novelty to see the turkeys, ducks, and geese that were only seen in other places dead and ready for the kitchen table. One of the delights of those visits was the abundance of fruit that I ate in big portions. Usually, the strawberries and raspberries were already gone, but there were still redcurrants and cherries. And the apple trees, the pear trees, and plum trees were full of ripe, beautiful and succulent fruit. What are the different parts of the ranch? The house, the backyard, the premises, and the countryside that surrounded the house. What do the premises consist of? They consist of the stables, the sheepfold, the pigsties, and the hen runs. What is, according to you, the most useful of the domesticated animals? I think it is the cow, not just because it gives milk, but also because the milk is transformed into butter and cheese. And besides, beef is an important part of our everyday diet.

Didn't your uncle have bees? No sir. When he moved to the ranch thirty years ago, he bought a huge quantity of bees. But the honey did not give him much of a return, so he sold them. Did he have big plots of irrigated land? No, just the one that was behind the house. But it was very productive and every year it reaped large quantities of fruit and vegetables. Try an apple. Or, do you prefer plums? There are some green ones here, if you like them better than the ripe ones. They are very sweet, thanks. I am going to take one of these apples. The pears and apples are the pieces of fruit that I like the most.

References

- Araujo, Fernando. 1894. *Estudios de Fonética Castellana*. Toledo, Spain.
- Bradley, Travis G. 2004. Gestural timing and rhotic variation in Spanish codas. In *Laboratory Approaches to Spanish Phonology*, ed. T. L. Face, 197–224. Berlin: Mouton de Gruyter.
- Bradley, Travis G. 2005. Systemic markedness and phonetic detail in phonology. In *Experimental and Theoretical Approaches to Romance Linguistics*, ed. R. Gess and E. Rubin, 41–62. Amsterdam: John Benjamins.
- Bradley, Travis G. 2007. Spanish complex onsets and the phonetics-phonology interface. In *Optimality-Theoretic Studies in Spanish Phonology*, ed. F. Martínez-Gil and S. Colina, 15–38. Amsterdam: John Benjamins.
- Bradley, Travis G., and Benjamin Schmeiser. 2003. On the phonetic reality of /t/ in Spanish complex onsets. In *Selected Proceedings of The Sixth Hispanic Linguistics Symposium*, ed. P.M. Kempchinsky, J. Liskin-Gasparro and C.E. Piñeros, 1–20. Somerville, MA: Cascadilla Press.
- Browman, Catherine, and Louis Goldstein. 1989. Articulatory gestures as phonological units. *Phonology* 6:201–251.
- Browman, Catherine, and Louis Goldstein. 1990. Gestural specification using dynamically-defined articulatory structures. *Journal of Phonetics* 18:299–320.
- Browman, Catherine, and Louis Goldstein. 1991. Gestural structures: distinctiveness, phonological processes, and historical change. In *Modularity and the Motor Theory of Speech Perception*, ed. I.G. Mattingly and M. Studdert-Kennedy, 313–338. Hillsdale, New Jersey: Lawrence Erlbaum.
- Browman, Catherine, and Louis Goldstein. 1992. Articulatory phonology: an overview. *Phonetica* 49:155–180.

- Browman, Catherine, and Louis Goldstein. 2001. Competing constraints on intergestural coordination and self-organization of phonological structures. *Bulletin de la Communication Parlée* 5:25–34.
- Byrd, Dani. 1996a. Influences on articulatory timing in consonant sequences. *Journal of Phonetics* 24:209–224.
- Byrd, Dani. 1996b. A phase window framework for articulatory timing. *Phonology* 13:139–169.
- Byrd, Dani, and Elliot Saltzman. 2003. The elastic phrase: modeling the dynamics of boundary-adjacent lengthening. *Journal of Phonetics* 31:149–180.
- Byrd, Dani, Abigail Kaun, Shrikanth Narayanan, and Elliot Saltzman. 2000. Phrasal signatures in articulation. In *Papers in Laboratory Phonology V*, ed. M.B. Broe and J.B. Pierrehumbert, 70–87. London: Cambridge University Press.
- Colantoni, Laura, and Jeffrey Steele. 2005. Phonetically-driven epenthesis asymmetries in French and Spanish obstruent-liquid clusters. In *Selected Proceedings of the 34th Linguistic Symposium on Romance Languages*, ed. R. Gess and E. Rubin, 77–96. Amsterdam: John Benjamins.
- Colantoni, Laura, and Jeffrey Steele. 2007. Voicing-dependent cluster simplification asymmetries in Spanish and French. In *Segmental and Prosodic Issues in Romance Phonology. CILT Collection (Current Issues in Linguistic Theory, 282)*, ed. P. Prieto, J. Mascaró, and M.J. Solé, 109–129. Amsterdam: John Benjamins.
- Davidson, Lisa. 2003. The Atoms of Phonological Representation: Gestures, Coordination and Perceptual Features in Consonant Cluster Phonotactics. Doctoral Dissertation, Johns Hopkins University.
- Gafos, Adamantios. 1999. *The Articulatory Basis of Locality in Phonology*. New York: Garland.
- Gafos, Adamantios. 2002. A grammar of gestural coordination. *Natural Language and Linguistic Theory* 20(2):269–337.
- Gili Gaya, Samuel. 1921. La r simple en la pronunciación española. *Revista de Filología Española* 8:271–280.
- Goldstein, Louis, Dani Byrd, and Elliot Saltzman. 2006. The role of vocal tract gestural action units in understanding the evolution of phonology. In *From Action to Language: The Mirror Neuron System*, ed. M. Arbib, 215–249. Cambridge: Cambridge University Press.
- Hall, Nancy. 2003. Gestures and Segments: Vowel Intrusion as Overlap. Doctoral Dissertation, University of Massachusetts.
- Kilpatrick, Cynthia, James Kirby, and Kathryn McGee. 2006. Intrusive vowels in Cruceño Spanish. Paper presented at the 153rd Meeting of the Acoustical Society of America (ASA). Honolulu, HI. November 28–December 2, 2006.
- Krakow, Rena A. 1999. Physiological organization of syllables: a review. *Journal of Phonetics* 27:23–54.
- Lenz, Rodolfo. 1892. Chilenische studien. *Phonetische Studien* 5:272–293.
- Malmberg, Bertil. 1965. *Estudios de fonética hispánica (Collectanea Phonetica, I)*. Madrid: Consejo Superior de Investigaciones Científicas.
- Nam, Hosung, and Elliot Saltzman. 2003. A competitive, coupled oscillator of syllable structure. In *Proceedings of the 12th International Congress of Phonetic Sciences*, ed. M.J. Solé, D. Recasens, and J. Romero, 2253–2256. Barcelona, Spain: Rundle Mall, Causal Productions.
- Quilis, Antonio. 1970. El elemento esvarabático en los grupos [pr, br, tr]. In *Phonetique et Linguistique Romaines: Melanges offerts a M. Georges Straka*, 99–104. Lyon-Strasbourg: Société de Linguistique Romaine.
- Quilis, Antonio. 1993. *Tratado de fonología y fonética españolas*. Madrid: Editorial Gredos.
- Ramírez, Carlos J. 2002. Characterization of the epenthetic vowel between the clusters formed by stops/fricatives + flap in Spanish. In *Proceedings of the Annual Meeting of the Niagara Linguistic Society 19*, ed. B. Spreng, 67–74. Toronto, CAN: University of Toronto, Linguistics Graduate Course Union.
- Ramírez, Carlos J. 2006. Acoustic and perceptual characterization of the epenthetic vowel between clusters formed by consonant + liquid in Spanish. In *Selected Proceedings of the Second Conference on Laboratory Approaches to Spanish Phonetics and Phonology*, ed. M. Díaz-Campos, 48–61. Somerville, MA: Cascadilla Proceedings Project.
- Schmeiser, Benjamin. 2006. On the Durational Variability of Svarabhakti Vowels in Spanish Consonant Clusters. Doctoral Dissertation, University of California, Davis.
- Schmeiser, Benjamin. 2007a. The prosodic and segmental effects on gestural overlap in Spanish /rC/ clusters. Paper presented at Phonetics and Phonology in Iberia (PaPI) 2007. Universidade de Minho, Braga, Portugal. June, 2007.
- Schmeiser, Benjamin. 2007b. On the durational variability of svarabhakti vowels in Spanish complex onsets. In *Proceedings of the 33rd Western Conference on Linguistics (WECOL 2004)*, ed. M. Temkin Martínez, A. Alcázar, and R. Mayoral Hernández, 315–326. Fresno, CA: California State University Fresno Press.

Department of Languages, Literatures, and Cultures
Illinois State University
Normal, IL 61790
schmeiser@ilstu.edu