Contemporary Phonology in Brazil

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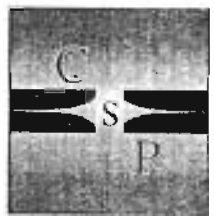

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CHAPTER TEN

ON THE NATURE OF EPENTHETIC VOWELS

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1. Introduction

This paper intends to contribute towards the evaluation of the representational status of epenthetic segments by focusing on a Brazilian Portuguese (BP) case study of epenthetic vowels. Epenthetic segments vary, in nature, from language to language. In the case of epenthetic vowels Japanese adopts *[u]*, English and Hebrew use *[ɨ]*, Spanish takes *[e]*, etc. The epenthetic vowel in Brazilian Portuguese is a high front vowel: *[i]*. To our knowledge no comprehensive experimental work has been done on this topic (Parlato, 2005–dealt with perception; Carvalho, 2005–considered the production of only four words). We intend to fill this gap in the literature by addressing the phonetic nature of epenthetic vowels in BP. We intend to show that durational values, adjacent consonants and prosodic structure are relevant parameters to define a high front vowel as an epenthetic one. Our results support claims from exemplar models regarding the relevance of fine phonetic detail in phonological representations (Johnson, 1997, in press; Pierrehumbert, 2001, 2003). In the second section we present the theoretical approach to be adopted in the paper and we identify the major research questions to be addressed. In section 3 we discuss the general distribution of high vowels in BP and we try to characterize the major acoustic characteristics of this vowel in previous works. Section 4 describes the methodological procedures adopted in collecting and analyzing the data. In section 5 results are explored in the light of the major theoretical claims. The conclusion is presented in section 6 indicating the major achievements of this paper.

2. The nature of the problem

A current issue in the literature in phonetics and phonology is the relationship between these two areas and how one may benefit from the other. A major line of research is carried out by Laboratory Phonology researchers who consider experimental evidence to corroborate phonological findings (Pierrehumbert, Ladd & Beckman, 2000). In this paper we intend to show that experimental results provide a more comprehensive analysis of epenthetic vowels offering a better understanding of their nature and distributional patterns.

Brazilian Portuguese has regular front vowels, epenthetic vowels and pretonic raised mid vowels which are all said to be phonetically manifested as a high front vowel. The major characteristics of these vowels will be addressed in the following section. What is relevant for the discussion presented here is that that regular high front vowels and epenthetic vowels are traditionally assumed to be phonetically identical differing just in their representational status: regular vowels are present and fully specified in phonological representations whereas epenthetic vowels are represented by an abstract segment that may or may not be phonetically manifested as a high front vowel (Collischonn, 2002).[2] The results presented in this paper show that epenthetic vowels differ from regular high front vowels with respect to fine phonetic properties, namely durational values. We argue that these results challenge the traditional view by suggesting that rather being considered as an abstract segment, as has been traditionally claimed, epenthetic vowels may be assumed to be present in phonological representations. In order to investigate the properties of epenthetic vowels we designed two sets of experiments which will be described in detail in section 3. These experiments are intended to address the issues listed below.

One of the issues we intended to investigate was whether regular vowels always occurred phonetically in contrast to epenthetic vowels. This is because the traditional assumption is that epenthetic vowels may or may not be pronounced whereas regular high front vowels are always pronounced. If such a distribution proceeds then the traditional assumption will be supported. This is because regular vowels, which would always be manifested, would be present in phonological representations. In contrast, epenthetic vowels, which are not phonologically represented, would or would not be pronounced under specific phonological conditions. On the other hand if both types of vowels, regular and epenthetic, may or may not be phonetically manifested, then one would have to predict under which conditions a regular high front vowel may be deleted. Furthermore, if

egular and epenthetic vowels may or may not occur in exactly identical nvironments, it will be difficult or arbitrary to determine when a high :ont vowel is either deleted or inserted. In order to answer this question ve evaluated the rate at which regular and epenthetic vowels may or may ot be pronounced. This result will provide us with evidence as to whether egular and epenthetic vowels should be present in phonological epresentations.

We then verified if the nature of adjacent consonants regarding voicing vould favor epenthesis. Second language studies on Brazilian Portuguese icquiring English showed that epenthesis was favored when an adjacent :onsonant was voiced (Baptista, B. & da Silva Filho, 2007). If a similar oehavior is to be observed in the native language, namely BP, then we vould expect a greater rate of epenthesis when voiced consonants occur. n this paper we considered native BP words where the adjacent :onsonants were (voiced-voiceless) and (voiceless-voiceless). Distributional restrictions did not allow us to consider cases where both vowels were voiced.[3] As we will see the analysis of epenthesis involving (voiced-voiceless) consonants and (voiceless-voiceless) ones proved to be interesting in relation to the rate of epenthesis. The results will allow us to consider whether epenthesis is implemented gradually by taking into consideration distributional properties such as voicing.

Another issue we addressed was whether regular and epenthetic vowels have similar or different acoustic characteristics. More specifically, we measured durational values for each one of the tokens collected. If regular and high vowels have the same acoustic properties then they could be related to the same phonological category. However, if there are consistent and regular differences between regular and epenthetic vowels one could suggest that the two types of vowels are actually distinct. We expected this result to offer evidence for the representational status of regular high front vowels and epenthetic vowels. We also considered the prosodic positions where epenthetic vowels occurred. We evaluated if epenthetic vowels occurred at different rates in the strong or the weak position of a foot. We expected epenthetic vowels to occur more frequently at the weak position of a foot where vowels may be shorter in BP (Faveri & Pagotto, 1999).

The discussion presented in this paper contributes to a better understanding of the relationship between phonetics and phonology and to the discussion on the nature of elements which are present in phonological representations. This paper also supports the view that the implementation of sound changes is phonetically gradual (Bybee, 2001). Finally, the relationship between distributional properties and the propagation of sound

changes is addressed. In the following section we discuss the distribution of high vowels in BP to identify major distributional patterns.

3. High front vowels in Brazilian Portuguese

In this section we consider the distribution and nature of high front vowels in BP. We also consider previous works that attempted to characterize these vowels acoustically. High front vowels have three potential sources in BP and we will refer to them as regular high front vowels, epenthetic vowels and pretonic raised mid vowels.

Regular high front vowels are always represented by the grapheme "i" and they occur in all possible environments: word initially (e.g. *ilha* "island"), word finally (e.g. *alibi* "alibi"), in the middle of words, in V syllables (e.g *saída* "exit"), in CV syllables (e.g. *pirata* "pirate", *capital* "capital"), in CCV syllables (e.g. *primo* "cousin", *lágrimas* "tears"), in CVC syllables (e.g. *mistério* "mistery", *afirmativa* "affirmative"). In Table 1 we present type frequency data of regular high front vowels in BP.[4]

The data in table 1 reflect the occurrence of intervocalic regular high front vowels where the first consonant in the sequence is listed on the leftmost column and the second consonant in the sequence is listed on the top row. Notice that regular high front vowels have a wide distribution with very few gaps. This implies in a high rate of occurrence in the language with a large range in the distributional system of segments. The total number of types for intervocalic regular high front vowels is 11.555. We will see shortly that epenthetic vowels have a much more restricted distribution.

Epenthetic vowels are always manifested as a high front vowel and they occur word initially (e.g. *script* > *[is]cript* "script/script") or word finally (e.g. *varig* > *vari[gi]* "Varig/the name of a Brazilian airline").[5] However, they typically occur between two obstruents separating two contiguous consonants. Some examples of words where epenthetic vowels occur are: *se[gm]énto* ~ *se[gim]énto* "segmento/segment", *cá[pt]o* ~ *cá[pit]o* "(eu) capto/(I) attract". Table 2 shows type frequency of epenthetic vowels.[6]

Table 2 shows that the distribution of epenthetic vowels is more restricted than the distribution of regular high front vowels (cf. table 1). This follows from the occurrence of a larger number of gaps in the distribution. It is also worth noting that the total number of types for epenthetic vowels is 3.788, being thus much smaller than the number of types of regular high front vowels (which is 11.555). Note, however, that in some cases where a single pair of consonants is considered the number of types for epenthetic vowels is greater that the number of types for regular high front vowels. This is the case, for example, for [kt] which counts just 41 types for regular high front vowels in contrast to 530 types for epenthetic vowels. We will see later that the number of types for a given category may be relevant for a better understanding of epenthesis in general.

Table 10-1,2

Table 1 Type Frequency of regular high front vowels

C2\C1	p	b	t	d	k	g	f	v	s	z	ʒ	m	n	Total
p	11	2	122	21	86	19	13	4	90	19	1	18	42	42
b	27	27	58	15	20	10	6	4	63	45	4	13	18	18
t	252	74	252	70	327	60	288	210	158	103	51	177	148	148
d	35	10	66	35	139	60	205	238	1008	44	76	109	52	52
k	8	4	41	18	8	2	-	31	52	58	1	11	11	11
g	-	-	6	2	-	-	-	-	5	-	-	2	2	8
f	-	8	25	36	379	100	-	4	248	51	-	0	0	179
v	52	13	93	169	18	41	3	52	136	171	21	37	37	20
s	20	144	141	184	187	62	174	81	205	40	20	142	142	205
z	-	26	51	38	24	39	4	17	143	-	8	6	6	9
ʒ	-	16	67	3	38	19	1	6	42	32	-	17	17	54
m	16	2	110	50	225	39	19	3	133	53	6	16	16	554
n	3	40	85	14	127	5	169	57	219	133	6	74	74	3
Total	424	366	1117	655	1578	456	882	707	2502	749	194	622	622	11555

Table 2 Type Frequency of epenthetic vowels

C2\C1	p	b	t	d	k	g	f	v	s	z	ʒ	m	n	Total
p	-	-	404	-	1	-	1	1	319	-	-	-	41	767
b	23	1	89	75	41	3	13	42	225	2	84	70	20	688
t	-	3	-	-	2	-	3	94	19	2	1	50	46	220
d	-	-	1	-	35	2	-	-	13	1	6	148	27	233
k	-	-	530	1	-	-	3	-	652	5	1	-	101	1293
g	-	1	3	10	-	-	1	-	2	-	-	116	424	557
f	-	-	23	-	5	-	-	-	-	-	-	1	1	30
Total	23	5	1050	86	84	5	21	137	1230	10	92	385	660	3788

Epenthetic vowels are always manifested as a high front vowel and they occur word initially (e.g. *script* > *[is]cript* "script/script") or word finally (e.g. *varig* > *vari[gi]* "Varig/the name of a Brazilian airline").[7] However, they typically occur between two obstruents separating two contiguous consonants. Some examples of words where epenthetic vowels occur are: *se[gm]énto* ~ *se[gim]énto* "segmento/segment", *cá[pt]o* ~ *cá[pit]o* "(eu) capto/(I) attract". Table 2 shows type frequency of epenthetic vowels.[8]

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We turn now to briefly consider cases in which a high front vowel comes from a pretonic raised mid vowel. In this case a high front vowel typically alternates with a front mid vowel: *p[e]rigo* ~ *p[i]rigo* "perigo/danger" or *cab[e]ludo* ~ *cab[i]ludo* "cabeludo/ haired". A number of works have looked at the raising of pretonic mid vowels in various BP dialects (cf. Oliveira, 1991; Viegas, 1987; Bisol, 1981; Bortoni et al. 1992). There is strong evidence that the raising of pretonic mid vowels in BP is lexically regulated (cf. Oliveira, 1991). Thus, whether or not a pretonic mid vowel is raised depends on the lexical item, the geographical area and even on the speaker's choices (Oliveira, 2007). Consequently, we are not able to present any evaluation of the distribution of pretonic raised mid vowels. We are not aware of any work that has dealt with a detailed

phonetic description of these vowels regarding articulatory and acoustic parameters. Therefore, although pretonic raised mid vowels are assumed to be a high front vowel we will not take it to be compared to the other cases of high front vowels addressed in this paper, namely, regular high front vowels and epenthetic vowels.

Regarding the acoustic characteristics of regular high front vowels and epenthetic vowels a number of works have dealt with it in a way that would not be satisfactory to be used as a model in the current paper. Moraes et al (1996) considered oral vowels data from various dialects evaluating male and female speakers. The city of Belo Horizonte, where our speakers come from, was not included in their sample. Faveri & Pagotto (1999) analyzed oral vowels from Santa Catarina dialect (Southern Brazil). Marusso (2003) consider speakers from Belo Horizonte but analyzed only four female speakers. The restriction imposed on sex and the small number of speakers led us not to consider her result as a model for comparison. Carvalho (2005) also considered speakers from Belo Horizonte but her data was very restricted being that she considered only three words for four speakers. However, an interesting finding in her work is that epenthetic vowels were shorter than regular high front vowels and that formant differences were not statistically significant between regular high front vowels and epenthetic vowels.

All the works we have just mentioned present methodological problems regarding the description of high front vowels. Thus, we proceeded to our data collection specifically designed to analyze durational patterns of both regular high front vowels and epenthetic vowels. The next section presents the major methodological points regarding data collection and analysis.

4. Methodology

Two experiments were designed to evaluate durational values of regular and epenthetic vowels. We selected three sets of consonants where the first consonant is a stop and the second consonant is an alveolar stop: [kt], [pt], [bt]. A regular high front vowel or an epenthetic vowel would or would not appear between the two consonants. The selection of the consonants in question was based on two criteria. The first one concerned the fact that both consonants involved were stops. For practical reasons it is more precise to measure durational patterns of vowels in between stops. This is because stops are represented by a blank space in the spectrogram and the vowel is clearly identifiable in between two stops. The second criteria used to select the two consonants was the high type count for them regarding

the voiceless stops sequences [kt] and [pt] (Table 2). Additionally, we selected the cluster [bt] to be contrasted to the cluster [pt] in order to evaluate whether voiced or voiceless consonants would favor epenthesis. Thus, in the experiments the following sequences were considered: [kt], [pt], [bt] and [kit], [pit], [bit], where a vowel could appear or not between the consonantal cluster and the vowel [i] could or could not be deleted in the sequences [kit], [pit], [bit]. The following section describes experiment 1.

4.1 Experiment 1

The main aim of experiment 1 was to characterize the rate in which a regular high front vowel or an epenthetic vowel occurs in similar contexts. We also consider if any segmental sequence would favor epenthesis. Finally, we considered durational patterns of regular high front vowels and epenthetic vowels. The experiment counted with 16 participants being 8 male and 8 female. There were two age groups: under 25 and over 35 years old. All participants were undergraduate students from the Federal University of Minas Gerais, born and living permanently in Belo Horizonte. In both experiments the analysis of sex and age did not show to be statistically significant. A set of 12 words were investigated being that 6 of which would present a regular high front vowel and 6 of which could present an epenthetic vowel. These words were: *Expectativa* "expectation", *Reinfectado* "reinfected", *Equitação* "horsemanship", *Emperequitada* "paraphernalia", *Optar* "to opt", *Readaptada* "readapted", *Apitar* "to whistle", *Apitadas* "whistled", *Obtenção* "procurement", *Obturação* "tooth cavity repair", *Habitação* "habitation", *Habituação* "habituation".

All words were recorded in a text and also in prosodically conditioned sentences. The total number of tokens to be considered in experiment 1 was 384.

4.2 Experiment 2

The main aim of experiment 2 was to investigate the rate at which an epenthetic vowel occurred in a corpus with a greater number of words. We also considered whether any segmental sequence would favor epenthesis. Durational patterns of epenthetic vowels were also evaluated and contrasted with findings from experiment 1. Finally, we analyzed durational values in relation to stress assignment within a foot. A group of 16 participants (8 male and 8 female), aged between 25 and 35 years old,

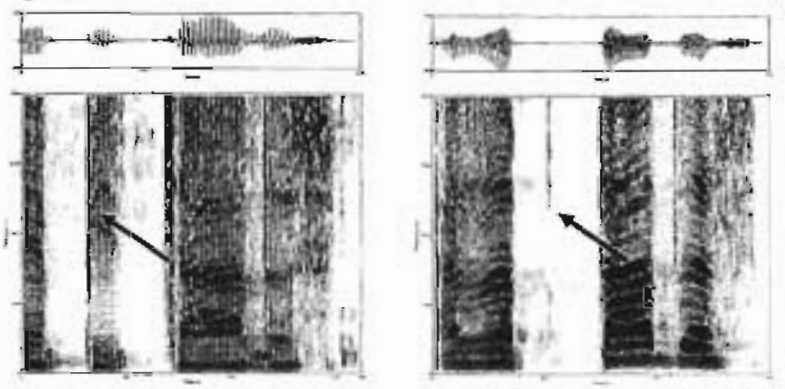
all undergraduate students who were born and lived permanently in Belo Horizonte were interviewed. Thirty-six words were analyzed being 12 with [kt], 12 with [pt], 12 with [bt]. These words were: a) 12 words with a [kt] sequence: *expectativa* "expectation", *intelectual* "intellectual", *espectador* "viewer", *característica* "characteristic", *infectologista* "infecteologist", *hectare* "hectare", *pactual* "the name of a Bank", *detector* "detector", *proctologista* "proctologist", *octagenário* "octagerarian", *pictograma* "pictogram", *conjectural* "conjectural"; b) 12 words with a [pt] sequence: *adaptação* "adaptation", *optar* "to opt", *captação* "captation", *ruptura* "rupture", *receptor* "receiver", *leptospirose* "leptospirosis", *captados* "captive", *capturado* "captured", *criptonita* "cryptonit", *cleptomaníaca* "cleptomaniac", *encriptar* "to encrypt", *preceptora* "preceptor" c) 12 words with a [bt] sequence: *obter* "to obtain", *obteve* "has obtained", *obteve* "obtained", *subterrânea* "underground", *subtrair* "to subtract", *subtexto* "subtext", *subterfúgio* "subterfugio", *obtuso* "obtuse, *obtermos* "we obtain", *obturados* "tooth cavity treatment", *subtópicos* "subtopic", *obtusidade* "being obtuse", *obtivéssemos* "if we obtained".

Regarding prosodic structure we considered secondary stress assignment as suggested by Segundo (1993): feet are left-headed and built from right to left. If we consider that the primarily stressed vowel is indicated in bold and underlined then, in a word like *apitar* "apitar/to whistle" secondary stress will be assigned as (s w). Similarly, in a word like *intelect(i)tual* "intelectual/ intellectual"–where the epenthetic vowel is indicated in parenthesis–secondary stress is assigned as (s s w s w). In our data an epenthetic vowel occurred in the weak position of the foot in twenty out of the 36 words and in the remaining 16 words an epenthetic vowel appeared in the strong position of a foot. Every word was recorded in prosodically conditioned sentences being that the total number of tokens was 576 tokens (36 words x 16 participants).

4.3 Data evaluation

The first evaluation of data considered whether or not a vowel occurred between the two stops in question. The spectrograms in Figure 1 show the case of the word "apitadas/ whistled". In this case a full high front vowel was expected (a), but we can see that sometimes like in (b) the vowel is not present.

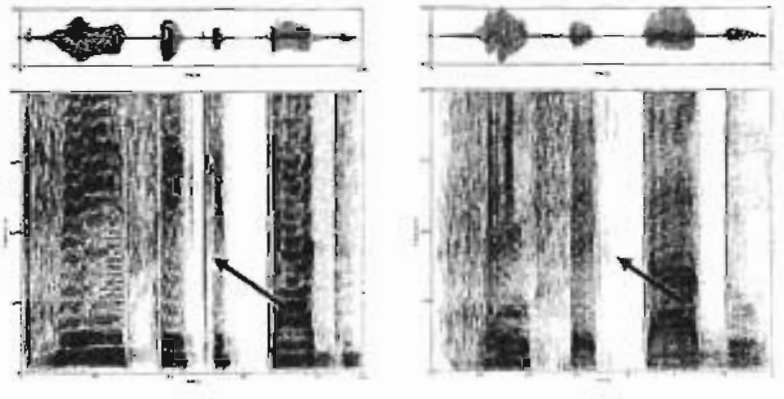
Fig. 10-1



(a) (b)

Figure 1 – Spectograms of the word "apitadas" *[apitadas]*. The arrow indicates presence or absence of the vowel. (a)With regular high front vowel (b) Without the presence of high front vowel.

Fig. 10-2



(a) (b)

Figure 2 – Spectograms of the word "reinfectado" [hcĩfɛktadu]. The arrow indicates the vowel.(a) Without the presence of an epenthetic vowel (b) Without the presence of an epenthetic vowel.

On the other hand, Figure 2 illustrates the case of the word "reinfectado/reinfected". For this case we would expected an epenthetic vowel like in (a), but sometimes we find an absence of a vowel like in (b).

In the cases where a vowel was attested the duration of each vowel was done using Praat (Boersma, P. & Weenink, D. (2007)). Each token measured had its values added to a chart whose data were later analyzed statistically using Matlab. In the following section we present the results for the questions we have drawn in section 2.

5. Results

We will first present results from experiment 1. The primary aim of this experiment was to investigate whether regular high front vowels and epenthetic vowels would occur or be omitted. Results are given in the table below:

Absence or presence of a vowel of regular high front vowel.

Table 10-3

	Regular high front vowel		Epenthetic vowel	
	N	%	N	%
Absence of vowel	8	4.2	41	21.4
Presence of vowel	184	95.8	151	78.6

Chi-square 25.48, p-value < 0.001

Table 3 indicates that both regular and epenthetic vowels may or may not be pronounced, although the general tendency is for a vowel to be present at a high rate (78.6%). We suggest that this fact reflects a general tendency observed in BP which favors CV syllables.[11] Regarding the omission of a vowel we observe the following rates: regular high front vowels 4.2% and epenthetic vowels 21.4%. The important fact to be noted here is that regular high front vowels may be omitted. As we discussed in section 2 this fact imposes problems to the assumption that regular high front vowels are present in phonological representations. Thus, we argue that this result provides us with evidence that both regular and epenthetic vowels should be present in phonological representations.

A second issue we intended to address in experiment 1 was whether the stop was voiced or voiceless would favor epenthesis. We indicated in section 2 that epenthetic vowels are favored in second language learning when voiced consonants are involved. Table 4 presents results concerning the property of voicing for the stops in question.

Absence or presence of a vowel-of epenthetic vowel.

Table 10-4

	kt, pt		bt	
	N	%	N	%
Absence of vowel	33	25.8	8	12.5
Presence of vowel	95	74.2	56	87.5

Chi-square 4.48, p-value < 0.05

A higher rate of epenthetic vowels is observed when one of the consonants is voiced, i.e. [bt], (87.5%). On the other hand, when both consonants are voiceless the rate of the occurrence of an epenthetic vowel is lower (74.2%). We suggest that this result indicates that distributional patterns are relevant in the implementation of epenthesis. That is, the phenomenon does not apply across the board in a general manner. Rather, epenthesis is implemented in a gradual fashion taking into consideration distributional patterns. In the case under examination whether or not the consonants involved are voiced is important, being that epenthetic vowels are favored when a voiced consonant is adjacent to it.

It is also worth noting that a property that is observed in second language acquisition in BP, namely epenthesis being related to the voicing of adjacent consonants, is also observed in BP itself. This gives us evidence that general patterns apply to a mother tongue as well as to second language learning. Finally, we considered data from experiment 1 to verify the durational patterns in regular and epenthetic vowels. Table 5 presents our findings.

Median of the duration for high front vowels and epenthetic vowels.

Table 10-5

	kt median(ms)	*pt* median(ms)	*bt* median(ms)	Total median(ms)
High Front Vowel (184 Tokens)	61.0	42.0	46.0	49.0
Epenthetic Vowel (151 Tokens)	32.0	27.0	28.0	30.0
p-value	1.4×10^{-12}	1.3×10^{-6}	3.6×10^{-5}	3.7×10^{-20}

The distribution of the duration of high front vowels and epenthetic vowels is not normal. Therefore, we performed a Wilcoxon rank sum hypothesis test, to verify if durational values were significantly different. The null hypothesis being H_0: $\mu_{\text{high front vowel}} = \mu_{\text{epenthetic vowel}}$, i.e., the median

duration of high front vowels and epenthetic vowels are the same, and the alternative hypothesis H_1 being: $\mu_{\text{high front vowel}} > \mu_{\text{epenthetic vowel}}$, i.e., regular high front vowels have a greater duration than epenthetic vowels. Note that the very low p-values lead to the rejection of the null hypothesis for all cases. In other words, this imply that the mean duration of high front vowels and epenthetic vowels are significantly different being that epenthetic vowels are shorter that regular high front vowels.

We suggested above that the fact that regular high vowels were phonetically manifested offered evidence for assuming that epenthetic and regular vowels are both present in phonological representations (cf. Table 3). Regarding the results presented in Table 5 we argue that they provide us with additional evidence that epenthetic and regular vowels are both present in phonological representations. We claim that speakers know whether the vowel is epenthetic or regular by the processing fine phonetic detail: epenthetic vowels are shorter than regular high front vowels. This result shows that both epenthetic and regular vowels are both present in phonological representations and that through processing fine phonetic detail speakers know whether the vowel is epenthetic or regular (Johnson 1997, in press, Pierrehumbert 2001).

We may summarize findings from experiment 1 as the following: a) both regular high front vowels and epenthetic vowels occur at a high rate favoring syllables CV, b) epenthesis is favored when one of the consonants in the cluster is voiced and c) epenthetic vowels are shorter than regular high front vowels.

We will then move to results from experiment 2. In this experiment only epenthetic vowels were analyzed. Four issues were investigated considering a greater number of words with an epenthetic vowel (in total 36 words for 16 speakers = 576 tokens). One of our aims was to compare results from experiment 1, regarding the rate of occurrence of epenthesis and the duration of the epenthetic vowel, with data from a larger set of tokens. We also intended to verify the relevance of prosodic structure in the implementation of epenthesis.

Table 6 indicates that epenthesis occurs in 73.6% of cases. In experiment 1 we noted that this rate was 78.6%. Thus, we may conclude that epenthesis applied to a similar rate in both experiments favoring syllables CV.

Absence or presence of an epenthetic vowel.

Table 10-6

	kt		*pt*		*bt*		Total	
	N	%	N	%	N	%	N	%
Absence of vowel	60	31.3	69	35.9	23	12.0	152	26.4
Presence of vowel	132	68.7	123	64.1	169	88.0	424	73.6

Chi-square 31.80, p-value < 0.001

Table 6 also provides us with further evidence for the claim that epenthesis is favored when one of the consonants is voiced: [bt] = 88%, [kt] = 68% and [pt] = 64.1%. This supports the claim that distributional properties are relevant in the implementation of epenthesis. More specifically, we find that epenthesis is favored when one of the consonants is voiced.

We would also like to suggest that type frequency may play a role in the implementation of epenthesis. In Exemplar models (Johnson 1997, Pierrehumbert, 2001) a higher type count strengthens a pattern yielding to a stronger representation which is less likely to change. If we look at Tables 1 and 2 we find the following type frequency: [kit] = 41, [kt] = 530; [pit] = 122, [pt] = 404; [bit] = 58, [bt] = 75. The fact that [kt, pt] have a higher type count than [kit, pit] may contribute to [kt, pt] to present a lower rate of epenthesis. This is because the high type count strengthens representations. On the other hand, [bt] has a low type count and could have a weaker representation. Further research is still needed on this topic. Consider now data from table 7 which gives durational values of epenthetic vowels.

Median duration for high front vowels and epenthetic vowels.

Table 10-7

	kt median(ms)	*pt* median(ms)	*bt* median(ms)	Total median(ms)
Epenthetic Vowel (151 Tokens)	30.0	28.5	43.0	33.5

The general durational rate for epenthetic vowels is 33.5ms which is similar to the rate found in experiment 1 (30.0ms). We may thus conclude that epenthetic vowels are definitely shorter than regular high front vowels (whose duration was 49.0ms in experiment 1). This result supports the claim that regular high front vowels and epenthetic vowels are both present in phonological representations and that through processing fine

phonetic detail speakers know whether the vowel is a regular high front vowel or an epenthetic vowel. What distinguishes one from another are durational values: epenthetic vowels are shorter than regular high front vowels.

We also examined in experiment 2 if it would be relevant whether the epenthetic vowel occurred in the weak or in the strong position of a foot. We expected epenthetic vowels to occur at a higher rate in the weak position of a foot where vowels may be shorter in BP (Faveri & Pagotto, 1999). Table 8 presents our findings.

Relations between epenthetic vowels and position of foot.

Table 10-8

	Strong Foot		Weak Foot	
	N	%	N	%
Absence of Vowel	89	34.8	63	19.7
Presence of Vowel	167	65.2	257	80.3
Duration median(ms)	30.0		37.0	

Chi-square 16.65, p-value < 0.001

Table 8 shows that epenthetic vowels occur at a higher rate in a weak position of a foot (80,3%) rather than in strong ones (65,2%). This indicates that epenthetic vowels are favored in the weak position of a foot. In order to certify that this result is correct we performed a Wilcoxon rank sum hypothesis test, to verify if durational values are significantly different. The null hypothesis being H0: μstrong foot = μweak foot, i.e., the median duration of epenthetic vowels in the weak position and in the strong position are the same, and the alternative hypothesis H1: μstrong foot > μweak foot according to which the median duration of epenthetic vowels in a strong position of a foot differs from the median duration of epenthetic vowels in a weak position of a foot. The p-value for this test was 2.26x10-5, which lead us to reject the null hypothesis and conclude that the median duration of epenthetic vowels in the weak position of a foot differs from the median duration in the strong position of a foot. This corroborates our claim that epenthetic vowels are favored in the weak position of a foot and it also shows that epenthetic vowels are longer in the weak position of a foot rather than in a strong one. We suggest that prosodic distribution of epenthetic vowels is also important in the implementation of epenthesis.

We may summarize findings from experiment 2 as the following: a) the rate of occurrence of epenthetic vowels and their durational values were corroborated in experiment 2, b) epenthesis occurred at a higher rate in the weak position of a foot and c) epenthetic vowels in the weak position of a foot were longer than in the strong one. In the following section we present the major results from this paper.

6. Conclusion

This paper intended to be a contribution towards the evaluation of the representational status of epenthetic segments by focusing on a Brazilian Portuguese (BP) case study of epenthetic vowels. The analysis presented showed that both, regular high vowels and epenthetic vowels may or may not be pronounced. However, the presence of a vowel is favored indicating a general tendency in BP which favors CV syllables. We suggest that this result provides us with evidence for regular high front vowels and epenthetic vowels to be present in lexical representations.

It was also shown that epenthetic vowels are significantly shorter that regular high front vowels. We claim that this result gives evidence for incorporating fine phonetic detail in lexical representations as suggested by Exemplar Models (Johnson 1997, in press; Pierrehumbert 2001).

Another finding is that epenthesis is favored when one of the adjacent consonants is voiced. This finding gives us evidence that a general pattern apply to a mother tongue as well as to second language learning since a similar property was found amongst Brazilians learning English (Baptista & da Silva Filho, 2007). We also showed that epenthesis is favored in the weak position of a foot. Finally, we suggested that type count may also be important in the implementation of epenthesis but this issue still deserves further consideration.

The results presented in this paper contribute to the current debate on the relationship between phonetics and phonology and also indicate that fine phonetic detail may be present in phonological representations (Johnson 1997, in press; Bybee, 2001, Pierrehumbert 2001).

Notes

[1] The authors would like to thank financial support for this research from CNPq – Brazilian National Research Council grant numbers 303397/2005-5, 2CNPq and 507038/2004-5.

[2] Regarding raised pretonic mid vowels, such as in p[e]rigo > p[ɪ]rigo "danger", the major claim is that the high vowel is underlyingly a mid vowel (Oliveira, 1991).

[3] A full account of distributional possibilities of epenthetic vowels in BP will be presented in the following section.

[4] The data presented in Tables 1 and 2 come from a database designed to investigate phonological distributions in BP (www.projetoaspa.org). The source corpus for this database consists of 228 million tokens with a set of 192.000.

[5] In two words an epenthetic vowels has been reported to be manifested as [e]: *pneu* > *p[e]neu* "tire" and *advogado* > *ad[e]vogado* "lawyer". In both cases it is observed that the high front vowel may also occur as [i].

[6] Restriction on the first consonant in Table 2 reflect the fact that epenthetic vowels are not preceded by [ɷ,σ,ζ,Z,μ,ν].

[7] In two words an epenthetic vowels has been reported to be manifested as [e]: *pneu* > *p[e]neu* "tire" and *advogado* > *ad[e]vogado* "lawyer". In both cases it is observed that the high front vowel may also occur as [i].

[8] Restriction on the first consonant in Table 2 reflect the fact that epenthetic vowels are not preceded by [ɷ,σ,ζ,Z,μ,ν].

[9] In two words an epenthetic vowels has been reported to be manifested as [e]: *pneu* > *p[e]neu* "tire" and *advogado* > *ad[e]vogado* "lawyer". In both cases it is observed that the high front vowel may also occur as [i].

[10] Restriction on the first consonant in Table 2 reflect the fact that epenthetic vowels are not preceded by [ɷ,σ,ζ,Z,μ,ν].

[11] Vowel nasalization, L-vocalization, R-deletion, Postvocalic-S deletion are phenomena which corroborate this tendency.

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