

# A question of syllable structure: contextual acquisition of English /p/ and /k/ in a laboratory setting

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## Abstract

Using a laboratory approach, this study investigates the acquisition of the stops /p k/ by Brazilian Portuguese (BP) learners of English in three contexts: in word-medial position before (1) /t/ or (2) /n/ and (3) in word-final position. Because BP allows only /S r l N/ in these positions, learners tend to resort to a process of i-epenthesis (e.g., *cha[pi]ter*, *te[ki]nique*, *magi[ki]*). While /p k/ clearly syllabify as onsets after i-epenthesis, there is no consensus on their syllabic affiliation in the target contexts. Three views can be distinguished. According to orthodox phonology, /p k/ syllabify as codas in all three locations. From the Government Phonology view, however, /p k/ are codas only word-medially before /t/; in the other two contexts, they syllabify as onsets of empty nuclei. Finally, Strict CV proposes that /p k/ in all three cases are onsets of empty nuclei. In previous research,<sup>1</sup> we established that /p k/ are acquired differentially in medial position before /t/ and in final position, the latter being the more challenging context. This finding provides tentative support for the Government Phonology claim that /p k/ instantiate a different syllabification in these two contexts and hence constitute a distinct learning challenge. To explore the matter further, we include here the context of /p k/ in word-medial position before /n/. A set of non-word-learning tasks and pre/post production tests determine that this context patterns with word-final consonants, as the Government Phonology view predicts. Statistical results support the prediction.

**Keywords:** L2 phonological acquisition, syllable structure, vowel epenthesis.

1. JOHN and CARDOSO, “Medial Coda and Final Stops in Brazilian Portuguese-English Contact” (2017).

## Resumo

Utilizando-se de um tratamento experimental, este estudo investiga a aquisição das oclusivas /p k/ por aprendizes de inglês, falantes nativos de português brasileiro (PB), em três contextos : em posição medial de palavra antes de (1) /t/ ou (2) /n/ e (3) em posição final de palavra. Como o PB permite apenas /S r l N/ nessas posições, os aprendizes tendem a recorrer à epêntese da vogal /i/ (e.g., *cha[pi]ter*, *te[ki]nique*, *magi[ki]*). Enquanto /p k/ claramente se comportam como onsets silábicos depois de /i/ epentético, não há consenso sobre sua afiliação silábica nos contextos-alvo. Podem-se elencar três visões distintas sobre o fato. De acordo com modelos

fonológicos ortodoxos, /p k/ se comportam como codas em todos os três contextos. Por outro lado, pela Fonologia de Governo, /p k/ são codas apenas em posição medial de palavra antes de /t/. Nos outros dois contextos, eles ocupam a posição de onset dos núcleos vazios. Finalmente, o modelo CV Estrito propõe que /p k/ em todos os três casos sejam onsets dos núcleos vazios. Numa pesquisa anterior,<sup>2</sup> afirmamos que /p k/ são adquiridos de modo diferente em posição medial antes de /t/ e em posição final, sendo este último um contexto mais desafiador. Este achado fornece subsídios para o argumento da Fonologia de Governo segundo o qual /p k/ instanciam uma silabificação diferente nos dois contextos e, portanto, constituem um desafio distinto no processo de aprendizagem. Para explorar melhor esta questão, incluímos aqui o contexto /p k/ em posição medial de palavra, antes de /n/. Um conjunto de tarefas de aprendizado de logatomas e testes de pré e pós-produção determinam que este contexto se molda a consoantes finais de palavra, como prevê a Fonologia de Governo. Resultados de testes estatísticos corroboram essa previsão.

**Palavras-chave:** aquisição fonológica de L2, estrutura silábica, epêntese vocálica

2. JOHN e CARDOSO, “Medial Coda and Final Stops in Brazilian Portuguese-English Contact” (2017).

## Introduction

Adopting a laboratory approach for the investigation of phonology, this article reports on the findings of a study into the acquisition of the stops /p k/ by Brazilian Portuguese (BP) learners of English in three locations: (1) word-medially before /t/ (e.g., *cha[p]ter*, *do[k]tor*), (2) word-medially before /n/ (e.g., *a[p]nea*, *Coc[k]ney*), and (3) word-finally (e.g., *bisho[p]*, *magi[k]*) — see forthcoming discussions for the rationale for selection of these contexts. In learning English as a second or foreign language (L2), BP speakers do not have to acquire /p k/ as segments, since these are part of the BP phoneme inventory. Nonetheless, they do need to expand the contexts in which /p k/ (among other consonants) can appear, since BP permits these stops only in word-initial and word-medial onset position (see [p] *agar* ‘to pay’, [k] *ara* ‘face’, *lu[p]a* ‘magnifying glass’, and *di[k]a* ‘hint’). English, on the other hand, as illustrated above, permits /p k/ in a wide range of contexts, including in word-medial position before /t/ or /n/, and in word-final position. In BP, only the restricted set of consonants /S l r N/ can appear in these contexts, and even then, they

are subject to variable processes of lenition (e.g., *paga/r/* → *paga[h]* ‘to pay’), including deletion (e.g., *paga/r/* → *paga[ ]*, where “[ ]” illustrates a deleted segment).

What do BP learners of English do when they encounter /p k/ (or other consonants) in the locations mentioned? The tendency, albeit variable, is to employ a process of i-epenthesis, which allows the consonant to be syllabified as an onset: *chapter* → *cha[pi]ter*, *Cockney* → *Coc[ki]ney*, *bishop* → *bisho[pi]*, and so on.<sup>3</sup> This process is found also in loanwords to BP (e.g., *laptop* → *la[pi]to[pi]*, *link* → *lin[ki]*) and in native words that contain /p k/ and other illicit consonants in these medial and final locations (e.g., *pacto* → *pa[ki]to* ‘pact’, *captar* → *ca[pi]tar* ‘to win’, *técnico* → *té[ki]nico*, *apnéia* → *a[pi]néia* ‘apnea’, *Varig* → *vari[gi]* Brazilian airline.<sup>4</sup> The phenomenon of i-epenthesis is thus a first language (L1) transfer process. [A]

In essence, acquisition of English /p k/ in these three locations constitutes a problem with syllable structure or, more precisely, with the set of consonants permitted in the respective syllabic contexts. In the phonological literature, however, there is no consensus on how to capture the syllable structure instantiated by these contexts. As will be discussed in greater detail below, the orthodox view is to consider as a *coda* the first consonant of any medial CC-cluster that does not form a branching onset (e.g., /pt/, /kt/, /pn/, /kn/), and the same coda analysis applies to word-final consonants.<sup>5</sup> The standard Government Phonology stance, on the other hand, is that codas are restricted to the first position in medial clusters with falling or level sonority (e.g., /pt/, /kt/); if they do not form branching onsets, first consonants in medial clusters with rising sonority (e.g., /pn/, /kn/) are *onsets of empty nuclei*, and the same syllabification applies to final consonants.<sup>6</sup> Finally, Strict CV, which is an off-shoot of Government Phonology, proposes that phonological representations only contain *CV strings*, amounting to sequences of non-branching onsets and nuclei.<sup>7</sup> Strict CV thus considers /p k/ in all three of the contexts under study as Cs followed by contentless Vs (i.e., as onsets of empty nuclei).

A central aim of the study reported on here is to collect empirical evidence to elucidate which of the different syllabic analyses holds. In other words, as will be discussed later, we employ laboratory phonology methods,<sup>8</sup> combined with a variationist approach to L2 data analysis,<sup>9</sup> to inform a contentious issue in phonological theory. In the spirit of variationist sociolinguistics,<sup>10</sup> we likewise investigate various internal and external factors that may

3. Among others, MAJOR, “Paragoge and degree of foreign accent in Brazilian English” (1986).

Authors’s notes are indicated by capitalized letters; they may be found at the end of the text, on p. 141.

4. CANTONI and SILVA, “Verbal Stress Assignment in Brazilian Portuguese and the Prosodic Interpretation of Segmental Sequences” (2008); CRISTÓFARO-SILVA and ALMEIDA, “On the nature of epenthetic vowels” (2008); NEVINS, “Book review: ‘A lateral theory of phonology: what is CVCV and why should it be?’ by Tobias Scheer” (2008).

5. BLEVINS, “The syllable in phonological theory” (1995); SELKIRK, “The Syllable” (1982).

6. HARRIS and GUSSMANN, “Final codas: why the west was wrong” (1988); KAYE, “‘Coda’ licensing” (1990).

7. E.g., LOWENSTAMM, “CV as the only syllable type” (1996); SCHEER, *A lateral theory of phonology: what is CVCV and why should it be?* (2004).

8. E.g., PIERREHUMBERT, BECKMAN, and LADD, “Conceptual foundations of phonology as a laboratory science” (2000).

9. E.g., JOHN and CARDOSO, “Medial Coda and Final Stops in Brazilian Portuguese-English Contact” (2017).

10. E.g., LABOV, *Social Factors* (2001).

condition i-epenthesis probabilistically.

The three proposed syllabic parses make different predictions for acquisition. Under the orthodox coda analysis, we would expect BP learners of English to acquire /p k/ more or less simultaneously in the three contexts, since these contexts represent a unified learning challenge: widening the set of coda consonants to include /p k/. The same simultaneous acquisition would be anticipated under Strict CV, although in this case, /p k/ are analyzed as onsets of empty nuclei in the three environments. Under the standard Government Phonology analysis, on the other hand, we would expect medial coda /p k/ (i.e., in /pt/-/kt/ sequences) to be acquired separately from /p k/ in medial onset clusters (/pn/-/kn/) and in word-final position (/p#/-/k#/). The latter two should be acquired more or less together, since they both involve representing /p k/ as onsets of empty nuclei, albeit in separate locations (word-medial vs. word-final). The intricacies of these hypotheses will be explained in the next section.<sup>11</sup>

<sup>11</sup>. Background, p. 131.

A major aim of the current study then is to establish which of the predictions holds, thus contributing to our understanding of the probable syllabification of consonants in these contentious contexts. The crucial information that will help resolve the issue concerns rates of i-epenthesis. That is, although i-epenthesis is potentially categorical at the absolute beginner stage of English acquisition, typically it is a variable phenomenon, and rates of epenthesis slowly diminish as a function of increased proficiency, until the learner reaches an advanced stage of zero epenthesis (along the lines of MAJOR, 2001).<sup>12</sup> The learners we are interested in are those at the prolonged stages of variable i-epenthesis. In a nutshell, comparable rates of epenthesis across the contexts would be consistent with a common syllabic parse for /p k/ (whether as a coda or as an onset in all three cases); differential rates, with medial /pt-pk/ being acquired separately from medial /pn-kn/, and possibly with the latter acquired more or less simultaneously with final /p k/ would be consistent with the standard Government Phonology view.<sup>[B]</sup>

<sup>12</sup>. MAJOR, *Foreign accent: the ontogeny and phylogeny of second language phonology* (2001).

The next section provides more detailed background on previous studies on the phenomenon of i-epenthesis by BP learners of English, and it discusses the issue of syllabification in the three contexts at greater length. Following this, we present our methodology, including tasks involving reading aloud and elicitation of non-words, and the results of a **Goldvarb X** analysis,<sup>13</sup> followed by a discussion and conclusion in which further directions for

<sup>13</sup>. TAGLIAMONTE, *Goldvarb* (2016).

research are addressed.

## Background

Previous studies involving BP learners of English have tended to look at i-epenthesis following final consonants only.<sup>14</sup> The aim has been to establish the contextual factors that influence the phenomenon probabilistically. First, higher rates of epenthesis have been found after final voiced versus voiceless stops: b d g » p t k (where » indicates “more epenthesis than”, hence “acquired after”).<sup>15</sup> This finding accords well with the cross-linguistic tendency for voiceless consonants to be favoured in final position, as reflected in processes of final obstruent devoicing (for an overview of L2 devoicing).<sup>16</sup> Next, final non-coronal stops tend to trigger greater epenthesis: p b k g » t d.<sup>17</sup> The earlier acquisition of coronal stops presumably follows from the universally unmarked status of coronal place.<sup>18</sup> The two findings are also interesting because voiced /b g/ and coronal voiceless/voiced /t d/ are precisely the stops that, according to Government Phonology, do not occur in medial codas in English; only the voiceless non-coronals /p k/ do.<sup>19</sup> This view, incidentally, motivated our decision to limit the focus in the current study to the acquisition of /p k/.

Furthermore, stops at the end of monosyllabic words such as *pack* tend to trigger higher rates of epenthesis than at the end of di-/polysyllabic words such as *attack*: *pack* » *attack*.<sup>20</sup> The greater epenthesis in monosyllabic words points to the influence of a Word Minimality Constraint<sup>21</sup> that requires words to be minimally disyllabic (or, from the perspective that *pack* ends in an empty nucleus, to contain two phonetically realized nuclei). Since the effects of this constraint are found neither in BP nor in English, the phenomenon is best viewed as a case of the Emergence of the Unmarked in interlanguage.<sup>22</sup>

*A propos*, to avoid the influence of this constraint, our study compares rates of epenthesis after medial and final /p k/ in disyllabic forms only. As will be shown in the methodology section, the forms we used in the experiment are all non-words (parts of a miniature linguistic system), a move necessitated by the difficulty in identifying sufficient numbers of relatively high-frequency disyllabic words with /p k/ in the three contexts. In addition, the use of a miniature linguistic system in a laboratory learning setting allows us to control the input of the target language so that we can easily manipulate

14. For some exceptions, see BAPTISTA and SILVA FILHO, “The influence of voicing and sonority relationships on the production of English final consonants” (2006); HUF and ALVES, “A produção de /p/ e /k/ em codas simples e complexas do inglês (L2) por aprendizes gaúchos: discussão a partir de padrões acústicos encontrados” (2010); SCHNEIDER and SCHWINDT, “A epêntese vocálica medial em PB e na aquisição de inglês como LE: uma análise morfofonológica” (2010); and, most recently, JOHN and CARDOSO, “Medial Coda and Final Stops in Brazilian Portuguese-English Contact” (2017).

15. BAPTISTA and SILVA FILHO, “The influence of markedness and syllable contact on the production of English final consonants by EFL learners” (1997).

16. YAVAŞ, “Final stop devoicing in interlanguage” (1994).

17. CARDOSO, “The variable development of English word-final stops by Brazilian Portuguese speakers: a stochastic optimality theoretic account” (2007).

18. PARADIS and PRUNET, *The special status of coronals: internal and external evidence* (1991).

19. For a fuller explanation, see HARRIS, *English Sound Structure* (1994); HARRIS and GUSSMANN, “Final codas: why the west was wrong” (1988).

20. CARDOSO, “The variable development of English word-final stops by Brazilian Portuguese speakers: a stochastic optimality theoretic account” (2007).

21. MCCARTHY and PRINCE, “Prosodic Morphology I: constraint interaction and satisfaction” (1993).

22. BROSELOW, CHEN, and WANG, “The emergence of the unmarked in second language phonology” (1998); MCCARTHY and PRINCE, “The emergence of the unmarked: optimality in prosodic morphology” (1994).

it (quantitatively and qualitatively) to accommodate the demands of our study, to guarantee that the participants will not have had previous exposure to the target forms, and to control instruction so that participants receive the same type of exposure in which the three target contexts are manipulated. We recognize that while the use of non-words will cast doubt on the ecological validity and generalizability of our findings to everyday life, this approach will increase the reliability of our findings due to the complete control exerted on the targeted learning items. [C]

HUF and ALVES constitute an interesting exception to the usual focus on final consonants only.<sup>23</sup> They found higher rates of i-epenthesis after final (e.g., *tack* → *ta[ki]*) than penultimate stops (e.g., *tact* → *ta[ki]t*). Though the researchers assume the stops in both contexts to be codas, under the Government Phonology view, only the /k/ in kt-final *tact* would be a coda; the singleton /k/ in *tack* would be an onset of an empty nucleus. Indeed, the differential acquisition of stops in the two contexts provides tentative support for a distinct syllabic parse, the idea being that learners are faced with a dual learning challenge: they need to expand the set not only of coda consonants but also of onsets of empty nuclei.

Relatedly, our recent study<sup>24</sup> compared acquisition of medial coda versus final /p k/ in disyllabic words (e.g., *chapter*, *doctor* vs. *bishop*, *magic*). Considerably higher rates of i-epenthesis were found following final rather than medial coda stops: p#, k# >> p.t, k.t. We take this finding as further support for the Government Phonology view that /p k/ are syllabified differently in the two contexts: while in medial /pt-kt/ clusters, /p k/ are codas, in final position, they are onsets of empty nuclei. If simultaneous rather than differential acquisition had been observed in the two contexts, we would be inclined to assume a unified syllabification (either as orthodox codas or, as the Strict CV account contends, as onsets of empty nuclei in both locations). All the same, while simultaneous acquisition would falsify a separate syllabic parse for the two contexts, differential acquisition does not inexorably require a separate syllabic parse: arguably, differential acquisition could result from the acquisition of codas (or onsets of empty nuclei) representing a distinct learning challenge due to the two contexts. Perhaps final codas are simply more difficult to acquire than medial codas; perhaps final and medial codas are targeted by different constraints or parameter settings.

23. HUF and ALVES, “A produção de /p/ e /k/ em codas simples e complexas do inglês (L2) por aprendizes gaúchos: discussão a partir de padrões acústicos encontrados” (2010).

24. JOHN and CARDOSO, “Medial Coda and Final Stops in Brazilian Portuguese-English Contact” (2017).

It is for this reason that we resolved to widen the scope of our research in the study reported on here to include acquisition of medial /p k/ preceding /n/. Ultimately, we are interested in elucidating the following prosodic issue: What are learners acquiring exactly, when they develop the ability to represent and realize /p k/ in the three contexts (word-medially before /t/, word-medially before /n/, and word-finally) without an epenthetic vowel? We review the three views on syllabification that contend for recognition. Superficially, it looks like learners are developing the ability to syllabify and realize /p k/ in coda position. Indeed, according to orthodox accounts of syllabification,<sup>25</sup> any initial consonants in medial clusters that do not form branching onsets (e.g., the four sets under investigation: /pt/-/kt/ and /pn/-/kn/) are necessarily parsed as codas, and the same holds for final consonants.<sup>[D]</sup> This is not, however, the only option.

In Government Phonology,<sup>26</sup> notably, it has been suggested that final consonants are universally onsets of empty nuclei (i.e., nuclei devoid of segmental content).<sup>[E]</sup> Likewise, in this framework, only clusters with falling or (as with /pt/-/kt/ sequences) level sonority are possible coda-onset sequences. Clusters with rising sonority that do not form branching onsets, including /pn/-/kn/, are onset sequences separated by an empty nucleus.<sup>27</sup> Finally, according to the Strict CV approach,<sup>28</sup> which developed from standard Government Phonology, phonological representations are composed of sequences of alternating non-branching consonants and vowels. Hence any consonant sequences, including not only /pn/-/kn/ but also /pt/-/kt/ (and, indeed, apparent branching onsets), necessarily contain an intervening empty nucleus. The three analyses are summarized in table 1.<sup>29</sup>

	Orthodox phonology	Government Phonology	Strict CV
Medial /pt/-/kt/	p.t - k.t	p.t - k.t	pØt - kØt
Medial /pn/-/kn/	p.n - k.n	pØn - kØn	pØn - kØn
Final /p#/-/k#/	p. - k.	pØ - kØ	pØ - kØ

In brief, simultaneous acquisition of /p k/ in the three contexts, as reflected in similar rates of i-epenthesis across the contexts, would be consistent with a unified syllabic parse (whether as codas or as onsets of empty nuclei), and it would falsify the Government Phonology view that different syllabic representations are at work. Already we have established that medial /p k/ before

25. SELKIRK, “The Syllable” (1982); BLEVINS, “The syllable in phonological theory” (1995).

26. KAYE, LOWENSTAMM, and VERGNAUD, “Constituent structure and government in phonology” (1990).

27. HARRIS, *English Sound Structure* (1994).

28. LOWENSTAMM, “CV as the only syllable type” (1996); SCHEER, *A lateral theory of phonology: what is CVCV and why should it be?* (2004).

29. Cf. p. 133.

**Table 1:** Distinct syllabic parses for /p k/ in the three contexts (where p. or k. = coda; pØ or kØ = onset of empty nucleus).

/t/ have lower rates of i-epenthesis than final /p k/,<sup>30</sup> which provides tentative support for a distinct syllabic parse. The next step is to examine medial /p k/ before /n/: do these show similar rates of epenthesis to final /p k/, as we might expect if both are onsets of empty nuclei? Or do they show similar rates of epenthesis to medial /p k/ before /t/, as we would expect if they have the same syllabification as medial codas/onsets of empty nuclei? The following section outlines the methodology used to investigate these questions.

30. JOHN and CARDOSO, “Medial Coda and Final Stops in Brazilian Portuguese-English Contact” (2017).

## Methodology

Our multidimensional approach employs laboratory phonology methods for data collection, incorporating insights from generative phonology, variationist sociolinguistics, psycholinguistics, and second language acquisition, as will be described below.

## Participants

17 adult BP learners of English were recruited via social media to participate in the study. Ranging in age from 22 to 64 years, the participants were all living in Montreal (a second language context),<sup>[F]</sup> having moved there from Brazil the same year the data were collected (or, in the case of one participant, a year previously). Two participants indicated their level of English proficiency as intermediate; otherwise participants self-reported as beginners. In the call for participants, we expressly targeted lower level learners to avoid recruiting participants who may have moved beyond the i-epenthesis stage.

## Data collection and training (learning) sessions

Participants were recorded during tasks involving reading-aloud and elicitation of a set of twelve non-words, with /p/ or /k/ in word-medial position before /t/ or /n/ or else in word-final position. Four distractors were also included (see table 2).

As mentioned in the previous section, we chose to use non-words rather than, say, a real-word elicitation task for a number of reasons. First, were we to target real words in English, the medial /pn/ - /kn/ context is comparatively rare, so it would be difficult to elicit from participants sufficiently large sets of words showing

Final /p/ - /k/	Medial /pt/ - /kt/	Medial /pn/ - /kn/	Distractors
<i>galip</i>	<i>zeptu</i>	<i>sepna</i>	<i>kuvi</i>
<i>filop</i>	<i>gupta</i>	<i>lopni</i>	<i>basa</i>
<i>minek</i>	<i>mikta</i>	<i>beknu</i>	<i>nidu</i>
<i>redok</i>	<i>puktu</i>	<i>vakni</i>	<i>tola</i>

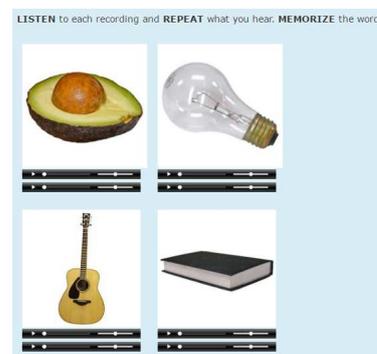
this pattern, especially since many of the existing words (e.g., *apnea*, *hackneyed*) are unlikely to be in participants' English lexicons. Another confound is that some of these words (e.g., *technique*, *picnic*, *apnea*) have cognates in BP, so the L1 lexicon could interfere with the pronunciation of the words in English. In addition, for reasons identified above, we wanted to restrict ourselves to disyllabic forms, even for words with final /p k/. Again, finding a large enough set of common disyllabic words proves difficult, whence the decision to employ non-words.

We now describe the steps observed for the instruction of the target forms and the data collection. Initially, participants were asked to read aloud the list of 16 non-words illustrated in table 2, using English pronunciation. Subsequently, over the course of at most one hour, participants completed four word-learning tasks (loosely based on those used in MATHIEU (2016) themselves based on SHOWALTER (2012), and SHOWALTER and HAYES-HARB (2013)).<sup>31</sup> The intended purpose of the tasks was to get the participants to develop lexical entries for a set of 16 invented words, which were associated with common images. They then underwent an immediate post-test which elicited production of all 16 non-words. Finally, they were asked to read aloud the list of non-words a second time.

The four word-learning tasks were set up in a quasi-gamified environment in **Moodle 3.0**, an online course management system.<sup>32</sup> First, participants were presented with a set of four randomized pages (using the quiz feature on **Moodle**) that they consulted one after the other. Each page contained a set of four common images selected from the Bank of Standardized Stimuli.<sup>33</sup> As illustrated in fig. 1, the images were accompanied by two sound files selected from recordings by three native speakers of standard North American English (2 male and 1 female). The sound files contained the non-word spoken in isolation and then at the end of a carrier phrase: for example, *Minek*, *this is a minek* (to accompany an image of an elephant). In the recordings, stress is placed consis-

**Table 2:** Non-words used in the study.

<sup>31</sup> MATHIEU, "The influence of foreign scripts on the acquisition of a second language phonological contrast" (2016); SHOWALTER, "The influence of novel orthographic information on second language word learning: the case of native English speakers learning Arabic" (2012); SHOWALTER and HAYES-HARB, "Unfamiliar orthographic information and second language word learning: a novel lexicon study" (2013).



**Figure 1:** Interface of learning task 1: Listen, repeat and memorize.

<sup>32</sup> <http://moodle.org>.

<sup>33</sup> BRODEUR et al., "The Bank of Standardized Stimuli (BOSS), a New Set of 480 Normative Photos of Objects to Be Used as Visual Stimuli in Cognitive Research" (2010).

tently on the syllable containing /p/ or /k/ (e.g., *gaLIP*, *MIKta*) to ensure clear articulation and optimal saliency. Participants would repeat the word after hearing each sound file and try to memorize it. They could click on the recordings as many times as they wished, before moving on to the next page, with the possibility of taking a short break between each set if needed. The participants were thus exposed to different voices and different realizations of the various words, the aim being to favour development of an abstract phonological representation of the words rather than facilitating phonetic imitation of individual tokens. The fact that the post-test involved elicitation rather than repetition was also intended to ensure the participants accessed a phonological representation stored (albeit very recently) in their lexicon.

Figure 2 illustrates the second word-learning task, which involved each image being presented one after the other in randomized order, along with two of the sound files used in Task 1, only one of which contained the correct identification of the image. The participants' task was to indicate which of the sound files was accurate and then submit their answer. If participants selected the correct sound file, they received the response *Excellent! Go to next question*, as shown in Figure 2. In the case of an incorrect selection, the response that appeared was *Incorrect! Please try again* (see fig. 3), in which case they were asked to listen again to relearn the correct form.

As fig. 3 suggests, Task 3 is the reverse of Task 2, involving two images shown with one sound file: the participants were asked to identify which image corresponded to the non-word spoken in the recording. Again, in the case of an incorrect answer, they re-listened to the file to reinforce learning.

For the final word-learning task, participants saw an image (again, in randomized order) and said aloud the non-word that they thought was associated with it. To facilitate the task, they were provided with the first two letters of the target word. They were also prompted to say the word in isolation and at the end of a carrier phrase. So, for the image of the pencil (*beknu*), they saw on the screen: *Be\_\_, this is a be\_\_*. They then clicked on a sound file to verify their response and to have a final opportunity to learn the non-word before the immediate post-test elicitation task. The interface of the last learning task is illustrated in fig. 4.

The post-test is identical to the preceding elicitation task, except that no sound file is provided to check answers (see fig. 5).

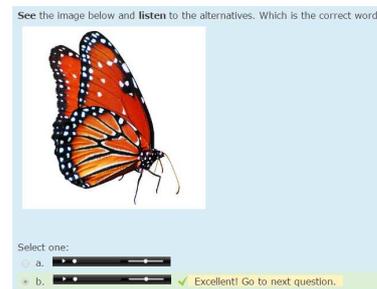


Figure 2: Interface of learning task 2: See and listen.

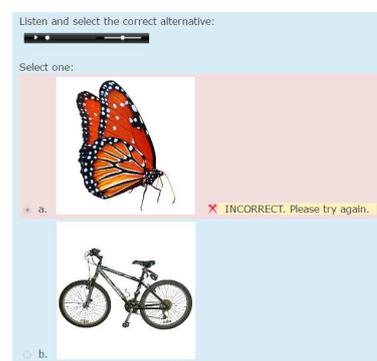


Figure 3: Interface of learning task 3: Listen and choose.



Figure 4: Interface of learning task 4: Speak, listen and check.



Ni\_\_, this is a ni\_\_.

Figure 5: Final production test: Post sentence-initial and sentence-final elicitation (an example).

Unfortunately, after the first four participants had engaged in the proposed learning activities, it became clear that very little word-learning was taking place. That is, participants had great difficulty recalling the correct non-words corresponding to the images, even with the cue of the first two letters. Whether this is due to a deficiency in the tasks (e.g., to their being restricted to a single session), to our failure to insist on the importance of actually learning the words, or to indolence on the part of the learners is hard to determine. Regardless of the explanation, we decided to reject the data from the first four participants, and we subsequently adapted the methodology of the post-test elicitation task: if a participant failed to recall the non-word or supplied an inaccurate form, the researcher flashed a card containing partial versions of the target word (i.e., without the target segment) so as to cue its production (e.g., *be\_nu* for *beknu*). While this modification to the data collection procedure considerably increased our intake of target tokens for the analysis, it was at the expense of collecting data that reliably reflect lexical representations. That is, in the recordings of the participants, we could no longer be sure that the person had accessed an actual lexical entry or had essentially been reading from the flashed card. In order to have usable preliminary data for the analysis, however, we were willing to live with the compromise, resolving to re-think our approach for subsequent stages of data collection (intended to take place in Brazil, in 2017).

The final task involved reading aloud the set of 16 non-words a second time. The pre- and post-reading-aloud recordings and the recording made during the non-word elicitation task constitute the full extent of the data collected for the **Goldvarb X** analysis, which we turn to next.

## Data analysis & results

The data were analyzed using **Goldvarb X**,<sup>34</sup> standard statistical software used in variationist/sociolinguistic studies.<sup>[G]</sup> **Goldvarb X** performs a regression analysis that identifies the relative contribution of different factors to the application of a variable process (such as i-epenthesis). Factor weights ranging from 0 to 1 are generated, with a weight in excess of 0.5 indicating that a factor is associated with higher rates of application (i-epenthesis in our case). For the purposes of the analysis, the data from the pre-reading aloud, post-elicitation and

<sup>34</sup>. TAGLIAMONTE, *Goldvarb* (2016).

post-reading aloud tasks (total: 618 tokens of medial or final /p k/) were coded for the dependent variable of i-epenthesis, along with the following independent variables shown in table 3.

Factor groups	Factors			
Position of /p k/	before /t/	before /n/	word-final	
Target C	/p/	/k/		
Task	pre-reading aloud	sentence-initial elicitation	sentence-final elicitation	post-reading aloud
Participant	1	2	3	4, etc.

**Table 3:** Factors included in the Goldvarb X analysis.

The various independent variables are those that may influence the frequency of application of i-epenthesis, with ‘position of /p k/’ being the factor group that interests us the most. As is customary in variationist research, the other factor groups were included primarily for exploratory purposes, rather than to address a specific research question. Nonetheless, the selection of further independent variables was not gratuitous. Comparing epenthesis rates for /p/ versus /k/ is based on the observation that place of articulation has been previously found to play a role in i-epenthesis. The task variable, with the elicitation data further coded for whether the token is sentence-initial (the non-word spoken in isolation) or sentence-final (at the end of the carrier phrase), was selected for two reasons: first, to verify whether extended experience with the spoken forms in the word-learning tasks influenced epenthesis rates in reading aloud; and, second, to check whether the more careful articulation associated with a word spoken in isolation (i.e., a more formal pronunciation) had an effect on epenthesis. The participant factor group was included to determine whether a range of epenthesis rates would be found across the participants and to potentially examine individual differences. This would be consistent with changes to the dynamic L2 phonological system that occur through developing proficiency.

In order to refine the analysis and to better identify the contributing variables, three runs of **Goldvarb X** were carried out. Two of the 13 participants retained for the analysis were eliminated following the first run, as they were found to have no instances of i-epenthesis; they had thus apparently already advanced beyond the stages of proficiency where i-epenthesis occurs. After the second run, the tasks factor group was eliminated (no signif-

icant difference was found in the data as a result of task). What is presented below in table 4 is thus the results of the third run, with two participants and the tasks factor group removed from the analysis. The remaining factor groups were selected by **Goldvarb X** in both step-up and step-down regression analyses, thus indicating that the selected groups in the third run are statistically significant for the phenomenon under investigation ( $p < 0.05$ ).

Factors	Factor Weights/ %			
Position of /p k/	before /t/ 0.299/ 14	before /n/ 0.648/ 31	final: 0.556/ 26	
Target C	/p/ 0.612/ 30	/k/ 0.386/ 18		
Participants	1: 0.142/ 4 5: 0.361/ 12 9: 0.670/ 32	2: 0.204/ 6 6: 0.485/ 19 10: 0.694/ 34	3: 0.261/ 8 7: 0.584/ 25 11: 0.956/ 79	4: 0.353/ 12 8: 0.642/ 30

**Table 4:** Factor weights and % assigned by **Goldvarb X**.

In brief, table 4 shows that higher rates of epenthesis were found: before word-medial /n/ (.648) and in final position (.556) as compared with before medial /t/ (.299); and after /p/ (.612) rather than /k/ (.386). In addition, a range of factor weights from very low (.142) to very high (.956) were found across the remaining eleven participants, thus indicating a high incidence of individual differences among them.

## *Discussion & conclusion*

The primary aim of the current study was to determine whether medial /p k/ appearing before /n/ show similar acquisition rates to medial /p k/ before /t/ or to final /p k/. Previously, as reflected in rates of i-epenthesis, we found differential acquisition for /p k/ in word-medial position before /t/ and in word-final position.<sup>35</sup> We argued that this finding is consistent with a distinction in the syllabic parse of /p k/ in the two environments: that is, as a coda in word-medial position but as an onset of an empty nucleus in word-final position, as proposed by Government Phonology. The findings thus appear to falsify the views espoused in both orthodox phonology and Strict CV, which propose a single syllabic parse for consonants in the two locations (i.e., either as codas or as onsets of empty nuclei in both cases).

Nonetheless, it could be argued that the differential

<sup>35</sup>. JOHN and CARDOSO, "Medial Coda and Final Stops in Brazilian Portuguese-English Contact" (2017).

acquisition observed derives not from any distinction in the syllable structure but rather from codas or onsets of empty nuclei being acquired separately in medial and final locations, perhaps due to different constraints or parameters being implicated. By examining i-epenthesis rates for medial /p k/ preceding /n/, we hoped to resolve the issue more satisfactorily. If /p k/ before /n/ are medial codas (the orthodox position) or medial onsets of empty nuclei (Strict CV), we might expect them to pattern with medial /p k/ before /t/. This is not what we found. Instead, medial /p k/ before /n/ pattern with final /p k/ in being more difficult to acquire than medial /p k/ before /t/. This finding is consistent with the Government Phonology position that, while medial /p k/ before /t/ are codas, medial /p k/ before /n/ and final /p k/ are both instances of onsets of empty nuclei. The portrait that thus emerges is that BP learners of English are faced with a dual challenge: on the one hand, they need to expand the set of coda consonants to include (among others) /p k/; on the other, they need to expand the set of consonants that can appear in an onset of an empty nucleus, whether medial or final.

The lower rates of i-epenthesis following /k/ versus /p/, indicating earlier acquisition of the velar versus the labial stop in the various contexts, is consistent with phonological investigations suggesting that, alongside coronal,<sup>36</sup> velar place cross-linguistically has special unmarked status.<sup>37</sup> It has been argued, for example, that in languages such as Selayarese,<sup>38</sup> when nasals do not receive a place specification via spreading from an adjacent consonant, they are receive velar place by default.<sup>39</sup> Our findings thus make an unexpected contribution to the debate over place markedness.

The considerable range in factor weights associated with individual participants, from a low of .142 to a high of .956, reflects the gradual acquisition behaviour that typifies interlanguage development.<sup>40</sup> Over time, as a function of increased proficiency, i-epenthesis rates gradually decline, and accurate production of target consonants steadily increases. Likewise, the fact that two participants showed zero epenthesis is indicative of the potential that interlanguage may eventually become in many ways target-like.

In sum, we hope that this study demonstrates how the use of laboratory phonology-inspired methods for empirical data collection can prove useful to address abstract debates in theoretical phonology. Specifically, we wished to test predictions derived from different

<sup>36</sup>. PARADIS and PRUNET, *The special status of coronals: internal and external evidence* (1991).

<sup>37</sup>. RICE, "Default variability: the coronal-velar relationship" (1996).

<sup>38</sup>. MITHUN and BASRI, "The phonology of Selayarese" (1986).

<sup>39</sup>. JOHN, "The Phonology of Empty Categories" (2014).

<sup>40</sup>. MAJOR, *Foreign accent: the ontogeny and phylogeny of second language phonology* (2001).

proposals on how to parse consonants, in our case the stops /p k/, in various positions in the word. We remain convinced that, if phonology is truly a science, the way forward is through controlled experiments that test whether hypotheses generated by different theoretical frameworks can be falsified.<sup>41</sup> On the issues addressed here, further research is anticipated. In particular, for a new phase of data collection in Brazil, we intend to refine the non-word-learning tasks so that actual development of new lexical entries is more successful; this should give us an even fuller portrait of the kinds of phonological representations learners are able to develop.

41. POPPER, *The Logic of Scientific Discovery* ([1959]1992).

## Endnotes

[A] We assume that i-epenthesis is categorical in BP, although the extent to which this is the case may depend on the regional variety. For example, the phenomenon may not be categorical in Belo Horizonte,<sup>42</sup> but this variety is notorious for reduction/deletion processes that are not instantiated in other regions.

42. Reported by CRISTÓFARO-SILVA and ALMEIDA, “On the nature of epenthetic vowels” (2008).

[B] Note also that, according to the Government Phonology syllabic parse, i-epenthesis serves a different purpose depending on the context: it involves either resyllabification of the coda consonant or else provision of vocalic content to an empty nucleus. According to the orthodox coda parse, only resyllabification is implicated; conversely, according to the Strict CV view, only expression of empty nucleus is taking place.

[C] For a discussion of the benefits and drawbacks of laboratory research methods such as the one employed in our study, see HULSTIJN (1997).<sup>43</sup>

43. HULSTIJN, “Second language acquisition research in the laboratory” (1997).

[D] It has been suggested that final consonants, at least in some cases, may be extrasyllabic appendixes; nonetheless, the extrasyllabic status of final consonants typically holds only at an early stage of the derivation — typically, they are eventually integrated into syllabic structure in an orthodox coda position.<sup>44</sup>

[E] KAYE (1990)<sup>45</sup> — though see PIGOTT (1999) for a more nuanced view.<sup>46</sup>

44. E.g., ITO, “Syllable theory in prosodic phonology” (1986).

45. KAYE, “‘Coda’ licensing” (1990).

46. PIGOTT, “At the right edge of words” (1999).

[F] Considering Montreal to be a second language context for English is in our view justified, although not straightforward. Though French is the sole offi-

cial language in the province of Quebec and Francophones form a considerable majority in most parts of the province, the situation is complicated in Montreal (the largest city in Quebec) by the presence of a sizeable English-speaking and immigrant population. Montreal consequently is anomalous in functioning to some extent as bilingual French-English, although the degree of French or English language use can vary considerably depending on the person, context, and even the area of the city. Importantly for our purposes, there is at least the potential for BP speakers to have contact with English on a daily basis.

**[G]** For a discussion of **Goldvarb X** in the analysis of L2 data, see CARDOSO (2007).<sup>47</sup>

<sup>47</sup>. CARDOSO, “The variable development of English word-final stops by Brazilian Portuguese speakers: a stochastic optimality theoretic account” (2007).

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