Confusion or mistiming? An exploratory study of the stops of Peruvian Quechua/Spanish bilinguals living in Brazil

Eleonora Albano, Antonio Pessotti & Carla Diaz
University of Campinas

This paper is a preliminary contribution to the phonetic and phonological description of Quechua stops. Given that all the available participants were Quechua/Spanish bilinguals, it is also a preliminary investigation of the effects of bilingualism on stop production in the two languages. Thus, it tests the import of a set of acoustic measures on the stop classes involved.

The acoustic description of Quechua is sparse and sketchy. An important gap concerns the distinction between plain, ejective, and aspirated stops. Ejectives involve a complex release mechanism and occur in about 18% of the world's languages [7]. However, the only available acoustic descriptions are preliminary, and refer to Bolivian Quechua [e.g., 3].

Here we address Peruvian Quechua against a bi/trilingual background. To this end, we designed a corpus contrasting stops in Quechua and Spanish. This consisted of nine minimal or near-minimal triplets/pairs for each language. All began with stops from one of the three shared places of articulation — labial, dental/alveolar, and velar —, followed by the vowels /i, a, u/. The target words were inserted in carrier sentences with saying verbs in each language.

The participants were ten Peruvian residents of São Paulo or Campinas, Brazil, 4 males and 6 females. They all spoke Portuguese with variable fluency. They fell into two groups: 5 Quechua speakers and 5 non-speakers. The former were bilinguals from Cuzco who had lived in Lima; the latter were from Lima and had been monolinguals up until moving to Brazil.

All participants were recorded with a Zoom H2n digital sound recorder in a sound treated room in their city of the residence. Their task was to read the carrier sentences, presented with flash cards in the orthography of the target language. Instructions were given in Spanish.

We analyzed the recordings with *Praat* [1]. After segmenting and transcribing the target segments and syllables, we made the four acoustic measurements deemed most useful by the literature on ejectives, viz: burst amplitude; VOT; H_1-H_2; and f_0 at vowel onset [2, 4, 5, 6].

We used *R* [9] to run the simplest possible generalized linear models [8] for each measure. The independent variables were aspirate, ejective, voiceless, and voiced. All stop class coefficients were significant for burst amplitude. The ejective, unlike the aspirate, had a non-significant coefficient for f_0, and was often non-significant. No measure separated them from aspirates in the Tukey test, though some separated them from other stops.

This is not only because both ejectives and aspirates have long VOTs in Quechua [2], but also because some intended ejectives looked like aspirates on the spectrograms and waveforms (see Figure 1). Table 1 summarizes such cases as a confusion matrix. We defined confusability by the presence of at least two of the following visual criteria: prolonged noise, missing (or masked) glottal release interval, missing (or masked) glottal burst.

We then removed such cases from the database and ran the GLMs again. Some expected distinctions appeared thereupon. In this run, f_0 and H_1-H_2 had significant coefficients for ejectives and set them apart from aspirates in the Tukey test. See error bars in Figure 2.

As to the effects of bilingualism, we examined Spanish with the Welch Two Sample t-test. Meaningfully, the same measures distinguishing aspirates from ejectives significantly distinguished Quechua speakers from non-speakers ($t = 6.69$ for H1-H2, and $t = 3.6855$ for f_0,). Nevertheless, the confusion matrix of Table 1 remained inconclusive up until recently, due to the absence of monolingual data for Quechua. Note that confusability may arise from real pronunciation errors or from the effect of mistiming (anticipation) of the glottal burst release. Now monolingual and bilingual data collected in Cuzco and Lima in July 2019 promise to clarify this issue. The rate of confusability in the monolingual group is negligible.

Figure 1 – Spectrograms and waveforms of the Quechua word *t'anta*, 'bread', pronounced with: (a) visible glottal release interval and (b) aspiration.

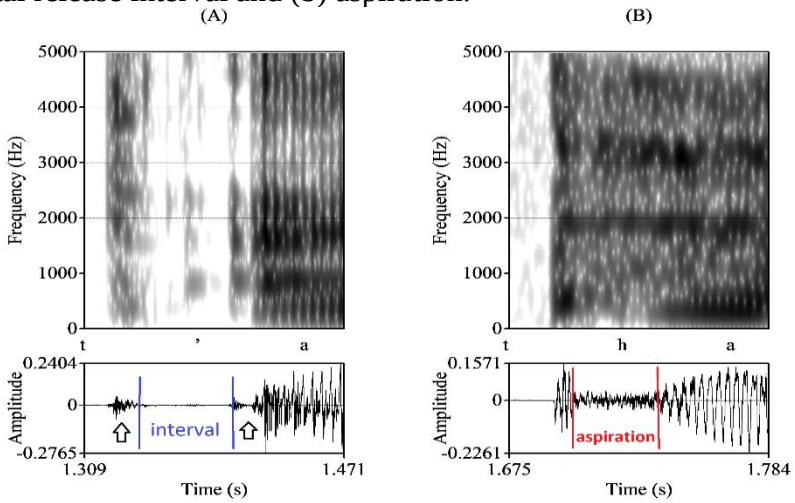
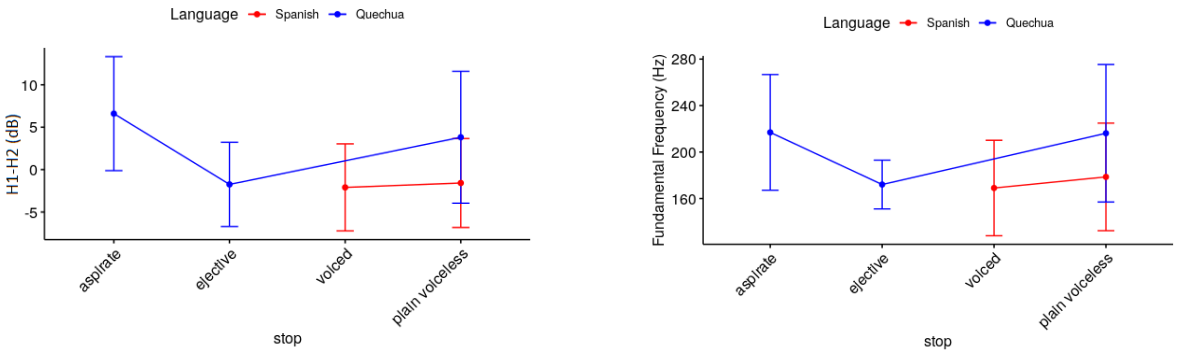


Table 1 – Confusion matrix of the Quechua stops based on visual inspection. Columns indicate *intended* stops; lines indicate *visual appearance*; percentages calculated over line totals.

Visual appearance / Intended stops	Ejective	Aspirate	Plain	Total
Ejective	35,56%	55,56%	8,89%	100%
Aspirate	4,44%	86,67%	8,89%	100%
Plain	0%	31,11%	68,89%	100%

Figure 2 – H1-H2 and f0 for all stop classes across languages and groups. Note the contrast between ejectives and aspirates. Note, in addition, that Quechua is slightly above modal voice, whereas Spanish is slightly below.



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