Follow-up studies to Gallagher (2016): 'Asymmetries in the representation of categorical phonotactics'. *Language* 92(3): 557-590.
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1 Overview

Gallagher (2016) compared native speakers' treatment of two types of unattested phonotactic structures in South Bolivian Quechua (henceforth Quechua): pairs of ejectives (*[k'ap'i]) and plain stops followed by ejectives (*[kap'i]). The original paper reports on the results of a repetition task and two discrimination tasks, and finds evidence for a stronger restriction (in the form of more errors that are phonotactic repairs) against pairs of ejectives than against plain stop-ejective pairs.

The two follow-up studies are a repetition task and an identification task that compare a fuller range of unattested phonotactic structures in the language. In Quechua, the three series of stops - plain, ejective and aspirate - are subject to a number of combinatorial restrictions, summarized in (1) and (2).

(1) Attested forms with ejectives and aspirates

a. initial ejective/aspirate, medial stop/fricative/sonorant

tʃ'uspi	'fly'	k^hutʃuj	'to cut'
q'osɲi	'oven'	k^hanij	'to bite'

b. initial fricative/sonorant, medial ejective/aspirate

rit'i	'snow'	jut^{h}u	'sparrow'

(2) Unattested forms with ejectives and aspirates: initial stop, medial ejective/aspirate

*k'ip'a	*k^hip^{h}a
*kip'a	*kip^{h}a
*k^hip'a	*k'ip^{h}a

The studies here use stimuli representing all of the unattested combinations in (2). Following up on Gallagher (2016), there are a few specific questions that these follow-up studies are meant to answer. First, do the asymmetries found between ejective-ejective and plain stop-ejective combinations also hold for aspirates? Second, how do mixed ejective-aspirate and aspirate-ejective combinations fit into the picture? Ejective-aspirate and aspirate-ejective combinations may be expected to pattern like ejective-ejective and aspirate-aspirate combinations, since all of these forms contain two laryngeally marked stops. This outcome would be consistent with an abstract representation of the restrictions being stated over a laryngeal node (MacEachern 1999), or a feature that groups ejectives and aspirates together, like [long VOT] (Gallagher 2011). On the other hand, individual combinations of laryngeally marked stops may be treated differently. This would be consistent with a narrower representation of the restrictions stated over smaller features and features combinations, or with a more phonetic interpretation of the restrictions.

2 Repetition task

Procedure and materials

In the repetition task, participants listen to a nonce word and asked to repeat what they heard as precisely as possible. Unlike in previous, published repetition tasks that I've published where participants heard each item pronounced twice on a single trial, in this iteration each item was only pronounced once. This is because in previous experiments participants frequently responded after the first presentation of the form, which meant they were producing the form while listening to the second repetition.

The participants were twenty Quechua-Spanish bilinguals. All participants reported being equally comfortable in both languages. The participants were 22-33 years old and were 15 females and 5 males, all recruited from the applied linguistics program at the Universidad Mayor de San Simón in Cochabamba, Bolivia. The experiment was conducted in a hotel room in Cochabamba, in a combination of Spanish and Quechua.

The target stimuli for the repetition task consisted of the 6 unattested stop combinations in (2), with 10 items for each combination. There were also 60 control forms that consisted of attested combinations of consonants. The stimuli are schematized in Table 1.

target stimuli					
ej-ej	k'ip'a	*asp-ej*	k^{h}ip'a	*pl-ej*	kip'a
asp-asp	k^{h}ip^{h}a	*ej-asp*	k'ip^{h}a	*pl-asp*	kip^{h}a
control stimuli					
ej-pl	k'ipa	*son-ej*	ʎap'a	*son-pl*	ʎapa
asp-pl	k^{h}ipa	*son-asp*	ʎap^{h}a	*pl-pl*	kipa

Table 1: Example stimuli for repetition task.

Results

Participants' repetitions were coded for accuracy and type of error, if any. Errors were classified for whether they repaired the phonotactic violation or not. The overall results for all errors are shown in Figure 1. Participants were near ceiling on controls, and made a comparable number of errors on all target stimuli.

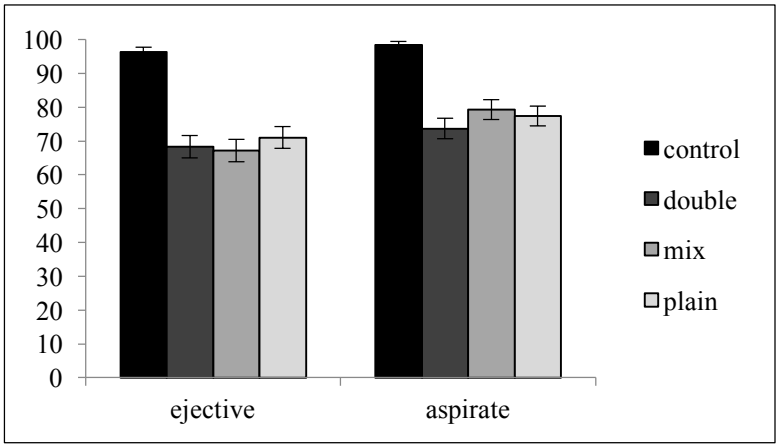

Figure 1: Accuracy on the repetition task.

Accuracy on the target stimuli only was compared in a mixed logit model was fit with a binary dependent variable of accuracy. The fixed effects were stimulus type (baseline "double" = ej-ej or asp-asp; "mixed" = ej-asp or asp-ej, "plain" = pl-asp or pl-ej) and laryngeal feature of the medial stop ("ejective" or "aspirate"). There were random effects of stimulus and participant. The model found a significant interaction between type="mixed" and laryngeal feature, so individual models were run for the medial ejective and aspirate stimuli, with a single fixed effect of type.

For stimuli with a medial ejective, there were no significant results. Neither ej-asp ($z = 0.39$, $p = 0.70$) nor pl-ej forms differ from ej-ej forms ($z = 1.23$, $p = 0.22$). For stimuli with a medial aspirate, accuracy on asp-ej forms is significantly higher than accuracy on asp-asp forms ($z = 2.11$, $p = 0.035$), but accuracy on pl-asp and asp-asp does not differ ($z = 1.64$, $p = 0.1$).

Repairs are shown in Figure 2. Ejective-ejective and aspirate-aspirate forms are repaired more often than other forms. A mixed logit model finds that this is a significant effect; no other differences among types or interactions with laryngeal feature are significant.

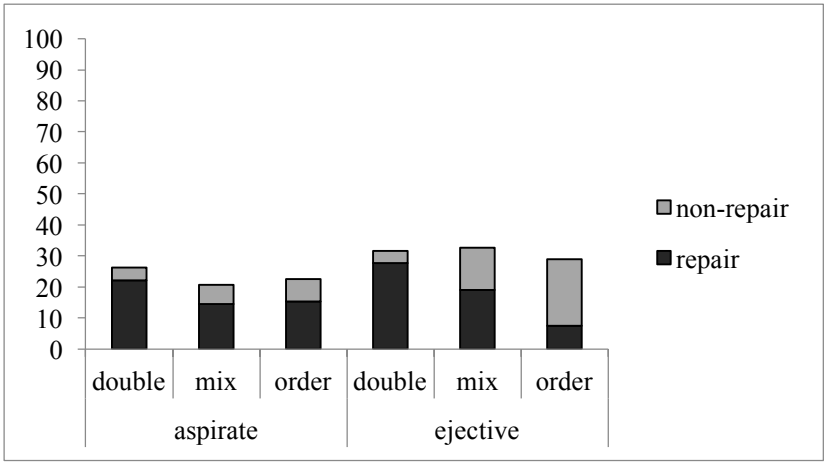

Figure 2: Repair and non-repair errors on repetition task.

Discussion

The results here are consistent with those reported in Gallagher (2016): ejective-ejective combinations are repaired more often than plain stop-ejective combination. This asymmetry extends to aspirates: aspirate-aspirate pairs are also repaired more often than plain stop-aspirate pairs.

Ejective-aspirate and aspirate-ejective combinations are found to pattern differently from ejective-ejective and aspirate-aspirate pairs. Like plain stop-ejective and plain stop-aspirate pairs, ejective-aspirate and aspirate-ejective pairs are subject to many non-repair errors. The errors made on each type of form are summarized in Table 2. Like plain stop-ejective and plain stop-aspirate forms, aspirate-ejective and ejective-aspirate forms are frequently misproduced with either a pair of ejectives or a pair of aspirates.

target	*repair*		*non-repair*	
k'ip'a	k'ipa	26%	kip'a	2%
	k^hipa	1%	k'ip^ha	3%
k^hip^ha	k^hipa	22%	kip^ha	1%
			$k^hip'a$	1%
			k'ip^ha	1%
k'ip^ha	k'ipa	13%	k^hip^ha	3%
	k^hipa	2%	kip^ha	1%
			k'ip'a	3%
$k^hip'a$	k^hipa	18%	k'ip'a	1%
	k'ipa	1%	k^hip^ha	13%
kip'a	k'ipa	6%	k'ip^ha	1%
	kipa	3%	k^hip^ha	1%
	k^hipa	1%	k'ip'a	18%
kip^ha	k^hipa	9%	k'ip^ha	1%
	kipa	5%	k^hip^ha	7%
	k'ipa	2%		

Table 2: Breakdown of errors for each target type.

The error data are somewhat conflicting. On the one hand, ejective-ejective pairs and aspirate-aspirate pairs are repaired most often, suggesting that the restriction against these combinations is the strongest. On the other hand, ejective-ejective and aspirate-aspirate pairs are common non-repair errors for other combinations, suggesting that these combinations are preferred in some way.

I would like to suggest that all unattested combinations are difficult to produce. In production, however, there is a preference for repeating the same laryngeal feature twice. That is, ejective-ejective and aspirate-aspirate forms are articulatorily preferred *among ungrammatical structures*. If this is true, then we can assume that some of the accuracy we see on ejective-ejective and aspirate-aspirate forms is actually do to this same articulatory preference. When a participant hears a form with laryngeally marked consonants in an unexpected combination, the articulatory preference is to repeat a single laryngeal feature twice.

Under this view, there is no conflict in interpreting the results. All unattested combinations are disprefered, but ejective-ejective and aspirate-aspirate combinations are disprefered more than the others. The overall accuracy data *overestimates* accuracy on ejective-ejective and aspirate-aspirate combinations, because some of these are default errors on difficult/unexpected forms. The more detailed error data show that not all errors are repairs; forms with an ejective or aspirate are prefered, and forms that repeat the same laryngeal feature in two positions are prefered. The frequent non-repair errors suggest that errors are not driven straightforwardly by the phonotactic grammar, instead, default articulatory preferences are also at play.

3 Identification task

Procedure and materials

In the identification task, 29 participants listened to a nonce word and were asked whether the word contained a [p], [p'] or [p^h]. All items contained a labial stop in medial position and no other labial stops. The participants were Quechua-Spanish bilinguals, recruited in the same way as for the repetition task (though they were different groups).

The stimuli were the same as those used in the repetition task.

Results

The results are shown in Tables 3, 4 and 5, divided by the target stop. Accuracy is high overall; accurate responses, which were the most common, are given in bold.

For forms with medial ejectives, accuracy is significantly lower on ejective-ejective (z = -2.78, p = 0.005) and aspirate-ejective (z = -4.87, p < 0.0001) forms than on controls; accuracy on plain-ejective forms does not differ from controls (z = -0.88, p = 0.38). When errors are made, they are largely *repair* errors for ejective-ejective pairs (12% [p] vs. 6% [ph]) and largely *non-repair* errors for aspirate-ejective pairs (17% [ph] vs. 11% [p]), as in the repetition task above and the overall conclusions of Gallagher (2016).

	p'	p^h	p
*k'ip'a	**82**	6	12
*k^{h}ip'a	**72**	17	11
*kip'a	**87**	7	6
ʎip'a	**88**	8	4

Table 3: Responses to forms with medial ejectives.

Forms with medial aspirates show a similar pattern. Accuracy is significantly lower on aspirate-aspirate (z = -2.32, p = 0.02) and ejective-aspirate (z = -2.42, p = 0.016) forms than on controls, but accuracy on plain-aspirate forms does not differ from controls (z = -0.44, p = 0.66). When errors are made, they are largely repairs for aspirate-aspirate forms (11% [p] vs. 3% [p']) and balanced between repairs and non-repairs for ejective-aspirate forms (7% [p] and 7% [p']).

	p'	p^h	p
*k^{h}ip^{h}a	3	**86**	11
*k'ip^{h}a	7	**86**	7
*kip^{h}a	5	**89**	6
ʎip^{h}a	3	**92**	5

Table 4: Responses to forms with medial aspirates.

The grammatical, filler forms with a medial plain stop also show an interesting pattern of errors. If the initial consonant was either a fricative, sonorant or a plain stop, accuracy was near ceiling. Forms with an initial ejective or aspirate triggered a good number of errors, with participants erroneously attributing the laryngeal feature of the initial stop with the medial stop (27% [p^h] responses to [k^{h}ipa]-type stimuli, 18% [p'] responses to [k'ipa]-type stimuli).

	p'	p^h	p
k^{h}ipa	4	27	**69**
k'ipa	18	4	**78**
kipa	0	1	**99**
ʎipa	3	1	**97**

Table 5: Responses to forms with medial plain stops.

Discussion

The identification results are consistent with the conclusions of Gallagher (2016): ejective-ejective and aspirate-aspirate pairs are more likely to be misperceived than plain-ejective or plain-aspirate pairs.

Overall accuracy on ejective-aspirate and aspirate-ejective pairs is similar to that on ejective-ejective and aspirate-aspirate pairs. As in the repetition task above, however, errors on ejective-aspirate and aspirate-ejective pairs are not always repairs.

Responses from forms with medial plain stops show that initial ejectives and aspirates trigger some number of ejective and aspirate responses. Given this, we can assume that some accuracy on forms like [k'ip'a] and [$k^h ip^h a$] is due to the initial segment not the target, medial segment. Similarly, we can assume that some or all of the non-repair errors on forms like [k'ip^ha] and [k^hip'a] are due to interferece from the initial stop. The lower rate of errors and on plain stop-ejective or plain stop-aspirate forms ([kip^ha] and [kip'a]) may then be due to the absence of a source of errors from an initial, laryngeally marked stop. This pattern suggests that participants are perceiving "ejection" and "aspiration" somewhat independently from the segment, at least for the purposes of this experiment. The presence of an ejective or aspirate anywhere in the form raises the number of ejective [p'] and aspirate [p^h] responses. This is consistent with the phonotactics of Quechua, in which the location of ejection or aspiration in the word is fully predictable.