The Ultra-High-Frequency Whistled /s/ of Southern Chilean Spanish: Socioeconomic and Gender Stratification of its Spectral Moments and Prevalence

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ABSTRACT

A typologically-anomalous whistled /s/ with a center of gravity (CoG) and/or spectral peak below 4.1 kHz has been described in a handful of languages. Additionally, in southern Chilean Spanish an ultra-high-frequency whistled /s/ (UHF [s̪]) with a CoG over 10 kHz was recently reported. This paper examines the effects of socioeconomic status (SES) and gender, as well as phonological context, on the prevalence and spectral moments of the Chilean UHF [s̪]. 40 speakers from five SESs were analyzed and mixed-effects linear regression analyses were performed. The prevalence of UHF [s̪] shows a significant direct correlation with both female gender and lower socioeconomic status. Its kurtosis is stable across speaker groups. Its CoG increases with female gender and middle SES, while decreasing in the highest SES. Its negative skewness, which is characteristic of this phone, is favored by female gender and non-upper SES. Lower standard deviation, also characteristic, is favored by female gender. The results suggest that UHF [s̪] operates as a sociolinguistic indicator.

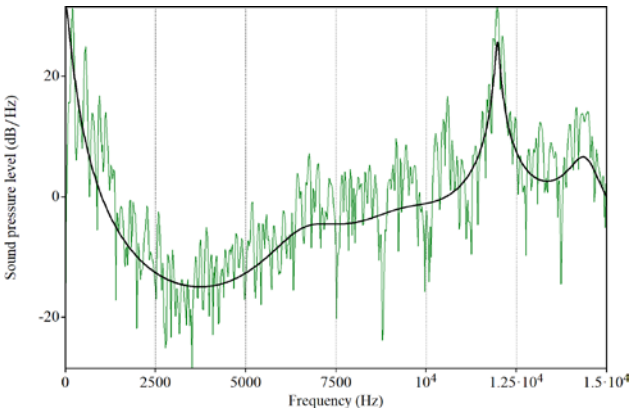
Keywords: UHF whistled /s/, spectral moments, Chilean Spanish, sociophonetics, language variation.

1. INTRODUCTION

The ultra-high-frequency whistled /s/ (UHF [s̪]) is a typologically unique phone that was first attested in Chilean Spanish speakers from the Concepción Province [11], although anecdotal evidence suggests a similar phone may manifest sporadically among certain users of presumably defective or ill-fitting dental prostheses. Acoustically, the Chilean UHF [s̪] is characterized by a center of gravity (CoG) above 10 kHz [10, 11], a markedly leptokurtic kurtosis, a low standard deviation (SD) and negative skewness [10] (Figure 1). These characteristics make it unlike any known fricative in Spanish, as well as any of the whistled fricatives described in other languages, such as those studied by Bladon, Clark & Mickey [1], Lee-Kim, Kawahara & Lee [5] and Shosted [12].

Regarding its use in southern Chilean Spanish, little is known beyond Sadowsky & Salamanca's [11] observation that it occurs predominantly among "lower-middle and lower SES female speakers".[1] With the exception of Sadowsky [9] and Sadowsky & Perdomo [10], there are no further mentions of UHF [s̪] in the scientific literature.

Figure 1: FFT and LPC spectral slices of UHF [s̪] in the word 'sentimiento'.



This paper examines the socioeconomic and gender stratification of the prevalence and spectral moment values of UHF [s̪] in speakers from the Province of Concepción, Chile, with the goal of shedding light on its origins, spread and social distribution throughout this population.

2. METHODS

The speaker sample consisted of 40 Spanish-monolingual life-long residents of the Province of Concepción, aged 16-24. A uniform quota sample was established using two independent social variables: speaker gender (50% female and 50% male) and socioeconomic status (SES) (20% per gender for each of five status levels). SES was calculated using the EMIS method [8]. The five levels used (A, B, Ca, Cb and D) can be interpreted as

[1] Translation ours.

extreme upper, upper, upper-middle, lower-middle and lower class, respectively.

Recordings, made at 44.1 kHz and 16 bits with a Studio Projects C1 large condenser microphone, an M-Audio FastTrack Pro interface and the Audacity software package [3], were then selected at random from the 40-60 minute conversational interview sections of the Sociolinguistic Corpus of Spoken Chilean Spanish (COSCACH) [7] until each sample quota was filled. The first 100 tokens of either the canonical alveolar [s] or the UHF [ʂ] from each speaker were analyzed. In practice, this meant that most tokens were located in syllable onset, as coda /s/ tends to be elided or realized as [h] in Chilean Spanish.

The 4000 resulting tokens were analyzed spectrographically and acoustically using the Praat software package [2]. Measurements were made of the central 80% of full non-whistled tokens and of the whistled portion of the remaining tokens, which was also approximately 80% of their duration. Tokens with a spectral peak below 8 kHz and a mesokurtic or platykurtic profile were classified as [s], while those with a spectral peak above 8 kHz and a leptokurtic profile were classified as [ʂ]. A custom Praat script discarded tokens presenting any type of coding error or other anomaly, and then measured the four spectral moments (CoG, SD, skewness, kurtosis) of each of the resulting 3686 usable tokens, with a 1 kHz high-pass filter, a 15 kHz low-pass filter, a smoothing factor of 100 and pre-emphasis starting at 1 kHz. An R [6] script was then used to eliminate extreme outliers, which were operationally defined as those whose kurtosis or skewness exceeded the 95th quantile, as well as cases of /s/ with a left or right phonological environment that occurred less than 10 times in the entire corpus. In all, 2940 tokens were included in the present study.

An additional R script calculated the prevalence and spectral moments of [s] and UHF [ʂ]. The results were then subjected to a series of mixed-effects linear regression analyses using the Rbrul software package [4], with gender and SES as social independent variables, left and right phonological environment as linguistic independent variables, and word as a random effect to control for lexical identity and frequency.

3. RESULTS AND DISCUSSION

3.1 Prevalence of UHF [ʂ]

UHF [ʂ] accounted for 9% (250) of the 2940 tokens analyzed (Table 1), making it a relatively infrequent allophone of /s/ in the speaker sample as a whole. However, its relative frequency was markedly higher in specific groups. The results of the regression model of the prevalence of UHF [ʂ] (Table 2) indicate that all four independent variables analyzed were statistically significant: gender (p=1.71×10^{-19}), left phonological environment (p=9.31×10^{-14}), SES (p=8.47×10^{-11}) and right phonological environment (p=9.84×10^{-3}).

Table 1: Prevalence of alveolar [s] and UHF [ʂ] by gender and SES.

		Alveolar [s]		UHF [ʂ]		Total	
Gender	**SES**	***n***	**%**	***n***	**%**	***n***	**%**
Female	A	255	97	9	3	264	9.0
	B	267	87	41	13	308	10.5
	Ca	268	85	46	15	314	10.7
	Cb	229	85	42	15	271	9.2
	D	254	81	58	19	312	10.6
Male	A	334	99	4	1	338	11.5
	B	262	98	4	2	266	9.0
	Ca	255	94	15	6	270	9.2
	Cb	262	90	28	10	290	9.9
	D	304	99	3	1	307	10.4
Total		2690	91	250	9	2940	100.0

Use of UHF [ʂ] is most favored by female gender (logodds = 0.673) and by lower-middle (Cb), lower (D) and upper-middle (Ca) SES (logodds = 0.644, 0.320 and 0.285, respectively). Extreme upper (A) SES, on the other hand, strongly disfavors its use (logodds = −1.239). With regard to linguistic variables, UHF [ʂ] production is most strongly favored by the left environments /l/, /n/ and /ɾ/, as well as by a preceding pause (logodds = 4.836, 4.467, 4.163 and 4.359, respectively). It is very strongly disfavored by the preceding close vowels /i/ and /u/ (logodds = −15.072 and −13.507). In the right phonological environment, all vowels but /u/ strongly favor the production of UHF [ʂ] (logodds = 5.785 or higher), while /u/ and a trailing pause very strongly disfavor it (logodds = −12.411 and −11.197).

3.2 Spectral moments of UHF [ʂ]

Kurtosis is probably the spectral moment most responsible for the whistled quality of UHF [ʂ], given that the concentration of energy that its high values entail is characteristic of whistled sounds in general, while also being the feature that differs most between this phone and the non-whistled alveolar [s]: as has been previously observed [10], [s] is platykurtic or mesokurtic, while UHF [ʂ] is leptokurtic. The regression analysis (Table 3) indicates that only the left phonological environment significantly influences the kurtosis of UHF [ʂ] (p=6.51×10^{-4}): the

most leptokurtic tokens are produced after /o/ (coef = 0.611), followed by /n/ and /ɾ/ (coef = 0.383 and 0.283, respectively).

Table 2: Mixed-effects linear regression model of the variation in the prevalence of UHF [ṣ].

Total *n*		2490
df		20
Intercept		−12.332
Factor	**Logodds**	***n***
Gender (p=1.71×10^{-19})		
Female	0.673	1469
Male	−0.673	1471
Left environment (p=9.31×10^{-14})		
l	4.836	55
n	4.467	256
##	4.359	337
ɾ	4.163	146
o	3.777	598
a	3.600	647
e	3.377	670
u	−13.507	38
i	−15.072	193
SES (p=8.47×10^{-11})		
Cb	0.644	561
D	0.320	619
Ca	0.285	584
B	−0.010	574
A	−1.239	602
Right environment (p=9.84×10^{-3})		
o	6.086	403
a	5.897	543
e	5.840	1077
i	5.785	826
##	−11.197	30
u	−12.411	61

At the other extreme, leptokurtic tokens are disfavored after /i/, /a/ and /e/ (coef = −0.594, −0.329 and –0.126, respectively), as well after a pause (coef = −0.273). Neither right environment, gender nor SES have a statistically significant effect on kurtosis. This lack of sensitivity to speaker group and following environment further points to kurtosis as being a prototypical feature of UHF [ṣ].

The CoG of UHF [ṣ] is what makes it ultra-high frequency. Its mean value is 10,215 Hz. The regression model of its variation (Table 4) shows a high degree of overlap with the independent variables that influence the prevalence of this phone. Thus female gender, which favors a higher prevalence of UHF [ṣ], also favors a higher CoG (+400.7 Hz), as do upper-middle (Ca) and, to a much lesser extent, lower (D) SES (coef = +426.3 Hz and +69.4 Hz, respectively). Contrarily, the extreme upper SES (A) favors a lower CoG (coef = −388.3 Hz). These results generally mirror those of prevalence and kurtosis, suggesting that the factors which favor the use of UHF [ṣ] co-vary with those that produce more prototypically UHF whistled realizations.

Table 3: Mixed-effects linear regression model of the variation in the kurtosis of UHF [ṣ].

Total *n*			545
df			19
Intercept			1.87
Factor	**Coefficient**	***n***	$\bar{X}$
Left environment (p=6.51×10^{-4})			
o	0.611	103	2.351
n	0.383	76	2.095
ɾ	0.283	44	2.118
l	0.045	22	1.880
e	−0.126	87	1.696
##	−0.273	87	1.542
a	−0.329	104	1.568
i	−0.594	22	1.235

As to phonological factors, the left environments /ɾ/ (coef = 240.4 Hz) and /n/ (coef = 117.1 Hz) favor a higher CoG, while /a/ (coef = −242.0 Hz) and /e/ (coef = −139.7 Hz) favor a lower one. Right environment does not have a statistically significant effect on CoG. With regard to skewness, Sadowsky & Perdomo-Pinto [10] found that [ṣ] is characterized

Table 4: Mixed-effects linear regression model of the variation in the CoG of UHF [ṣ].

Total *n*			545
df			19
Intercept			10,116
Factor	**Coefficient**	***n***	$\bar{X}$ **(Hz)**
Gender (p=1.7×10^{-16})			
Female	400.692	470	10,620
Male	−400.692	75	9,830
SES (p=8.06×10^{-9})			
Ca	426.265	132	10,848
D	69.391	113	10,550
B	−16.939	90	10,478
Cb	−91.307	195	10,323
A	−388.310	15	9,910
Left environment (p=8.73×10^{-3})			
ɾ	240.421	44	10,661
n	117.115	76	10,643
o	56.041	103	10,605
l	53.288	22	10,593
i	4.557	22	10,504
##	−89.715	87	10,571
e	−139.740	87	10,389
a	−241.967	104	10,295

by negative values, which is confirmed by the present study: all genders, SESs and environments have a negative skewness. More extreme negative skewness is favored mainly by lower (D) and upper-middle (Ca) SES (coef = −0.137 and −0.050, respectively); by preceding /ɾ/ (coef = −0.181), /o/ (coef = −0.101) and /n/ (coef = −0.059); and by a following /o/ (coef = −0.137) and /u/ (coef = −0.050). Notably, skewness differs from prevalence, kurtosis and CoG in that the gender correlation of the prototypically UHF whistled trait (a negative value in this case) is inverted: female gender *disfavors* it (coef = 0.124). This may indicate that skewness is of little perceptual salience to this phone's UHF and/or whistled qualities. The regression model for SD indicates that a lower value for this spectral moment, which is considered typical of UHF [s̪] by Sadowsky & Perdomo-Pinto [10], is favored by female gender (coef = −170.874), and to a lesser extent by extreme-upper (A) SES (coef = −86.837). This latter result, while relatively weak, does go against the trend of the highest SES disfavoring the prototypical traits of [s̪].

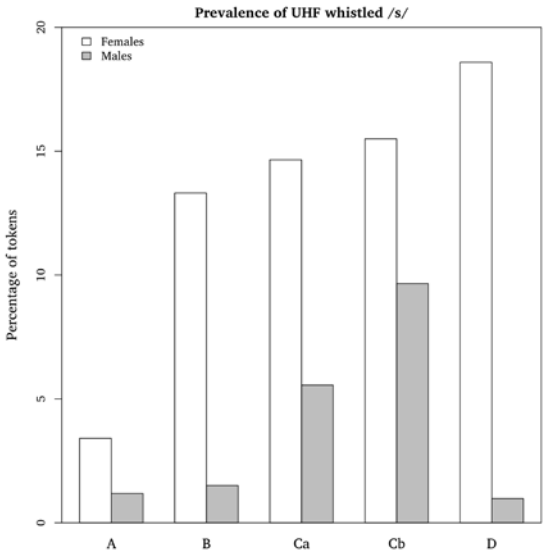
4. CONCLUSIONS

The multiple correlations that were found between speaker gender and/or SES, on the one hand, and the prevalence and most spectral moment values of UHF [s̪], on the other, strongly suggest that this phone's appearance in southern Chilean Spanish was due to sociolinguistic factors. Its prevalence offers perhaps the best illustration of this (Figure 2). The fact that UHF [s̪] occurs with far greater frequency in female speakers than in male ones suggests that it is a prestige-driven linguistic innovation, as per current sociolinguistic theory. Likewise, the fact that female speakers belonging to the extreme upper (A) SES use it the least, while also manifesting the lowest (least prototypical) CoG values when they do produce it, would seem to suggest that the prestige likely driving this change in the other SESs is, in fact, covert prestige. This may indicate that extreme upper (A) SES females are to some degree aware of the existence of [s̪] and have stigmatized it. There is no indication, however, of any such awareness in the other SESs, which points to this process being one of change from below.

The linear, monotonic distribution of UHF [s̪] prevalence rates among female speakers, which increase as SES decreases, suggests that this innovation first occurred in lower (D) SES women and spread upward in the socioeconomic hierarchy over time, until being rejected almost completely by the extreme upper (A) SES. It remains to be seen whether the adoption of UHF [s̪] by female speakers is still ongoing, or if it has stabilized.

The fact that UHF [s̪] prevalence is highest in the lowest SES, D, does not necessarily call into question the much-observed tendency for sociolinguistic changes to arise in interior SESs, because there is an additional SES, extreme lower (E), which could not be included due to its relative rarity (less than 5% of the Chilean population) and the major challenges accessing it poses. That said, very few sociolinguistic studies include an SES below "working class" or lower (D), and thus the present investigation may indeed have found evidence of a sociolinguistic change apparently initiated by an SES below the groups which typically do so.

Figure 2: Prevalence of UHF [s̪] by gender (color; white=females, gray=males) and SES (x-axis; highest is leftmost).



The fact that only two groups of males (upper-middle (Ca) and lower-middle (Cb) SES) use UHF [s̪] more than sporadically suggests that this change is still in progress among them. While the prevalence of this phone in male speakers need not ever reach the levels exhibited by females, it would be unsurprising if upper (B) and lower (D) SES men's use of UHF [s̪] increased sufficiently to parallel the prevalence rates of female speakers belonging to these same SESs.

It is noteworthy that the prevalence of UHF [s̪] in male speakers belonging to these two middle-class SESs neatly mirrors the rates of females of the same SESs. This further supports the idea that the adoption of this phone is driven by prestige.

Finally, in addition to further exploring the influence of social variables on the acoustic characteristics and distribution of UHF [s̪], future research should focus on determining precisely how this phone is produced. Given that it is apparently unique, logic dictates that its manner of articulation must be a new, previously unattested one.

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