STOP VOICING IN DREHU: EFFECTS OF PLACE OF ARTICULATION, SPEAKER SEX, AND LANGUAGE ATTITUDES

Catalina Torres[1], Jeremy Steffman[2]

[1]University of Zurich, [2]The University of Edinburgh
[1]catalina.torres@ivs.uzh.ch, [2]jeremy.steffman@ed.ac.uk

ABSTRACT

This study investigates a potential ongoing sound change in the language Drehu [d͡ʒehu], spoken by a small community in the South Pacific. We focus on the voiceless and voiced stop series in the language. Data from teenage female and male speakers was analysed in relation to voice onset time (VOT), percent voicing, and self reported language proficiency and attitudes. We find that the velar stops show substantial aspiration and de-voicing, led by female speakers. The voiceless velar stop shows the greatest VOT duration whereas voiced velars display the greatest devoicing. Interestingly, female and male speakers' increased use of VOT and devoicing are differently correlated to their language attitudes. This shows that in this small and rural community, the same features may have different socio-linguistic associations.

Keywords: stop voicing, voice onset time, Oceanic languages, language attitudes, sound change

1. INTRODUCTION

Drehu is an Austronesian language spoken by a population of around 15000 on the island of Lifou in New Caledonia. Like closely related languages Nengone and Iaai, Drehu is an Oceanic language of the Southern Melanesian group of the Loyalty Islands (LI) [1]. Grammatical descriptions [2, 3, 4, 5] have documented the phonological systems of LI-languages. However, their phonetic structure remains under-studied. Only few studies have dealt with their segmental inventories, thus showing a need for more instrumental work [6, 7]. Arguably, in Lifou, there are increasing linguistic pressures arising from bilingualism (with French) [8] and language contact, potentially influencing Drehu.

Drehu's phonetic structures are the perhaps best studied, especially considering its prosodic system [9, 10, 11]. Little is known on the acoustics of segments in the language, but a more recent study showed interesting results regarding earlier impressionistic descriptions. The previously documented retroflex stops (/ɖ, ʈ/) [12] were not confirmed in acoustic investigations [6] which instead reported affricate consonants [d͡ʒ, t͡ʃ]. An investigation a putative word-initial stress pattern [2, 13] failed to find evidence in favour of it, reporting a word-final prominence pattern instead [14]. While instrumental studies of Drehu have provided acoustic evidence deviating from early phonological analyses, the reasons for these observations are poorly understood. It is difficult to ascertain whether the results of these studies are due to prior description carried out impressionistically by fieldworkers without precise or quantitative approaches [15] or whether they are the result of ongoing sound changes. As [15] points out, small speech communities differ from large communities in that they have different social structures possibly leading to different phonetic and cognitive influences on sound change. This could, for example, influence the way sound change diffuses when there are fewer speakers in the community. This study investigates stop consonants in Drehu. We focus on the speech production of young (teenage) bilingual speakers while considering self reports on language proficiency and attitudes. With this we hope to contribute to a better understanding of how a potential sound change originates and spreads in a speech community of a small size while considering its particular ecology.

1.1. Stop consonants in the Loyalty Islands

Modern day Drehu is described as having a series of phonologically voiceless /p, t, k/ and voiced stop consonants /b, d, g/. Historically, the series of voiceless preceded that of voiced stops which were largely introduced through contact with neighbouring languages and borrowings from English [2, 12]. Regarding their phonetic characteristics, the bilabial /p/, alveolar /t/, and velar /k/ stops are considered to be voiceless and unaspirated, although [2] notes that voiceless

stops can sometimes be voiced intervocalically. Apart from an impressionistically recorded voicing distinction, no other feature is said to contrast the voiceless and voiced stop consonants. Since voiced stops were introduced to Drehu mostly through borrowings this explains the rather asymmetrical distribution between the voiceless and voiced stops, whereby voiceless stops are more common. One study [7] reports a series of voiceless /p, t̪, k/ and voiced /b, bʷ, d̪, g/ stop consonants in Iaai. Interestingly, the authors report evidence for retroflex stops (/ɖ, ʈ/) based on linguagrams. There are no instrumental studies dealing with the segmental inventory of Nengone but a relatively recent summary collected by a native speaker [16] provides an updated assessment. In Nengone, in addition to the voiced /b, d, g/ and voiceless /p, t̪, k/ contrast, there is a series of voiceless aspirated stops /pʰ, t̪ʰ, kʰ/. Additionally, the retroflex stops (/ɖ, ʈ/) also seem to be preserved. Finally a word on French, the contact language: lead voicing is used in voiced stops /b, d, g/ and voiceless stops aren't aspirated /p, t, k/ [17], though they can have lag VOT up to approximately 50 ms in some cases [18].

2. RESEARCH AIMS

We examine the acoustics of a series of voiceless /p, t, k/ and voiced /b, d, g/ stops. We focus on the measurements (i) voice onset time (VOT) and (ii) percentage of voicing during closure. We explore how place of articulation and speaker sex impact voicing and aspiration. We further investigate how self reported language proficiency and attitudes relate to acoustic realisations for female and male participants, suggesting a possible change in progress.

3. METHODS

3.1. Participants

Eight (4 female) teenage speakers (15-17 years) of Drehu took part in a speech production experiment. All are bilingual in French and Drehu, reported growing up speaking both languages from childhood, and self identify as Kanak. Participants were recruited at a local high school on the island of Lifou, where the speakers reported originating from. This is the only high school in the LI meaning that speakers of Iaai and Nengone are also represented.

3.2. Materials and procedures

A list of words, from which target tokens were selected, was created with the help of a native Drehu language expert. Participants were recorded individually performing a controlled reading task using experimental materials written in Drehu only. Stimuli appeared on a slide as individual sentences written in Drehu orthography. Target tokens were placed in the frame sentence *eni a qaja x me x nge x hmaca* 'I say x and x and x again'. The order in which sentences appeared was randomised. A head mounted microphone together with a Zoom H6 recorder were used. Recordings were made at a sampling rate of 44.1 kHz and 24 bit. Participants responded to an adapted version of the BLP [19], a questionnaire that collects self reported evaluations of bilinguals language proficiency and attitudes and provides scores for these categories.

3.3. Data processing, analysis, and statistics

Recordings were manually transcribed and forced aligned using the web MAUS interface [20]. Boundaries for segments were hand corrected. To identify and mark VOT we used AutoVoT [21] which was first trained on a subset of the Drehu data and was then used to mark VOT in all the data. Percent voicing in voiced stops was measured using the voice report functionality in Praat [22].

We used Bayesian mixed-effects regression analyses with the R package brms [23]. We report the median estimate from the posterior and the "probability of direction" computed with bayestestR [24]. This metric indicates the percentage of the posterior with a particular sign, ranging between 50 (posterior centered directly on zero) and 100 (posterior entirely excluding zero). The measure helps quantify with what certainty can we say that an effect shows a particular directionality. We take pd > 95 to be robust evidence for an effect, though we consider values approaching this threshold to provide weaker evidence for effect existence (e.g., if pd = 92 we can be 92% sure that an effect exists with a particular directionality). Models were run with four chains, an adapt-delta value of 0.99, and 4,000 iterations per chain, and a burn-in period of 1,000 iterations.

4. RESULTS

4.1. VOT measurements

The VOT model was run with the log-normal family to account for the log-normal nature of the VOT

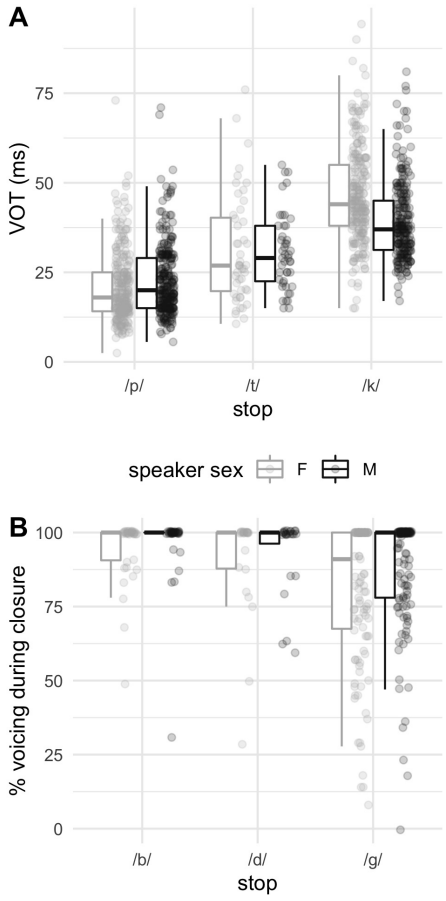

Figure 1: Top: VOT measurements in milliseconds for three voiceless stops /p, t, k/ for female (grey) and male (black) speakers. Bottom: % voicing for three voiced stops /b, d, g/ for female and male speakers.

data. With /p/ as the reference level in the model, there was a main effect of place of articulation, whereby /k/ had longer VOT (β = 0.73, pd = 100; β in logged values). There was also a credible difference between /t/ and /p/, with VOT in /t/ being longer (β = 0.35, pd = 100). We compared the VOT for /t/ and /k/ using the emmeans package [25] to compute the marginal effect between /t/ and /k/, finding that /k/ has credibly longer VOT than /t/ (β = 0.38, pd = 100). There was no main effect of sex in the model (pd = 82), however there was a credible interaction between sex and the place of articulation level /k/ (β = -0.26, pd = 100). There was no interaction between the place of articulation level /t/ and sex (pd = 80). As shown in Figure 2(A), this interaction comes from the fact that, only for /k/, female speakers produce longer VOT than male speakers. We examined the interaction further with emmeans, testing the effect of sex within each place of articulation, and finding that for /k/ there was some evidence for a difference across speaker sexes (β = 0.16, pd = 92), while for other places of articulation there was not evidence for a difference (pd = 82 for /p/, pd = 58 for /t/), cf. [26, 27].

4.2. Percent voicing

We used a zero-one inflated beta model for the % voicing data for /b, d, g/. This model family is appropriate for proportion or percent data in which there are some 0% and 100% measures. We used weakly informative priors. The data was converted to proportions, and was predicted as a function of place of articulation, speaker sex and their interaction. With /b/ as the reference level, there was a main effect of place of articulation, whereby /g/ showed a lower percentage of voicing during the stop (β = -0.53, pd = 98), with no credible evidence for a difference between /b/ and /d/ (pd = 88). Comparison with emmeans showed no credible difference between /d/ and /g/ as well (β = -0.15, pd = 75), indicating the /d/ is effectively in between /b/ and /g/ in terms of % voicing, with more devoicing clearly evident in /g/ versus /b/. There was no main effect of speaker sex (pd = 53), and only very weak evidence for an interaction of speaker sex with the /g/ place of articulation (β = 0.47, pd = 87). The directionality of the interaction is such that it suggests female speakers are producing more devoicing in /g/ than male speakers. Tests of the effect of sex within each place with emmeans corroborate this, showing weak evidence for a difference between female and male speakers in /g/ (β = -0.44, pd = 92), while for other places of articulation there was not evidence for a difference (pd = 52 for /b/, pd = 61 for /d/). Here we note that de-voicing generally occurred at the end of the stop closure, consistent with the aerodynamic voicing constraint [28].

4.3. Language proficiency and attitudes

A Pearson correlation coefficient was computed to assess the linear relationship between self-reported language proficiency in Drehu and duration in VOT. In the female speakers, there was a positive correlation between the two variables, (r(241) = .22, p = .0004). This correlation was only marginally present in the male speakers (r(160) = .04, p = .5 (n.s)). An additional correlation coefficient was calculated to assess the relationship between language attitudes in Drehu and % voicing. In the female speakers, there was a positive correlation between the two variables, (r(109) = 0.29, p = .002). The same test yielded an opposite result

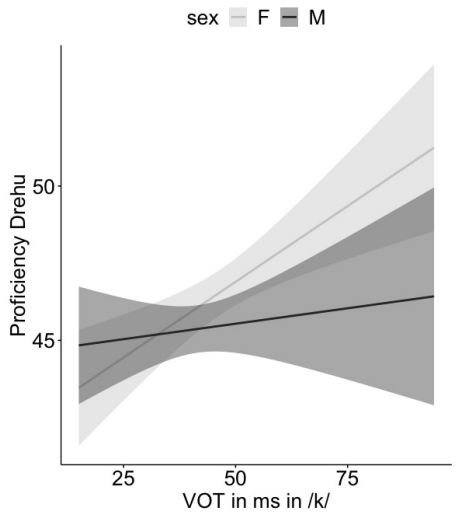

Figure 2: Linear relationship between language proficiency and VOT in /k/, for female (grey) and male (black) speakers.

for the male speakers (r(109) = -.32, p = .002). Finally, we were also interested in assessing whether language attitudes in French and % voicing could be correlated. There was a negative correlation, for the female speakers (r(109) = -.33, p = .0004). The test did not reach a significance level for male speakers in this case, although a negative trend was observed (r(86) = -.15, p = .1).

5. DISCUSSION AND CONCLUSION

This study examined the acoustic properties of voiceless and voiced stop consonants of teenage Drehu speakers. The results show that voiceless stops are produced with longer VOT, particularly /k/: mean VOT in /k/ is 47 ms for female speakers and 40 ms for males, making /k/ "slightly aspirated" in Cho and Ladefoged's taxonomy [29]. In parallel, we observe that phonologically voiced stops, particularly /g/, are sometimes partially devoiced. This may be evidence that cues to the contrast are changing, in line with the literature showing that sound change is a gradual phenomenon that first affects parts of the segmental inventory and not all segments of a series at once [30]. We find robust evidence for VOT in voiceless velar consonants /k/ to be longer than for other stops in the series /p, t/. Place of articulation is a possible factor influencing VOT duration, though notably [18, 31] find small and inconsistent differences between unaspirated /p/ and /t/. We find that young females show more aspiration and de-voicing. An interaction between place of articulation (for /k/) and female speakers was found showing that they produce longer VOT in the velar stop only. We further investigated the linear relationship of VOT with self reported language proficiency in Drehu. A positive correlation was found for female speakers. This suggests that female speakers who affirm having a higher proficiency in Drehu produce /k/ with longer VOT. This pattern was not found for male speakers. An analysis of % voicing in voiced stops showed that there is robust evidence for the voiced velar /g/ displaying greater devoicing than the bilabial and alveolar stops /b, d/. Effects of sex were also tested showing weak evidence that female speakers produce more devoicing than male speakers in the velar stop /g/ only, in parallel to longer VOT in /k/. An examination of a linear relationship between language attitudes towards Drehu and % voicing was carried out. In the male speakers we found a negative correlation whereby the more positively they view the Drehu language the less voicing they produce. There was a positive relationship in female speakers, suggesting that the more positively they view the language Drehu the more voicing they use. Additionally, in the female speakers it was found that there was a negative relationship between language attitudes in French and % voicing, showing that the more positively the speakers view the French language the less voicing they produce. Similar to observations in Western societies [32], we find that young females are leading a potential sound change. Although both young female and male speakers are involved in this potential sound change they seem to make somewhat different associations with the linguistic features involved. We find that in female speakers a better knowledge of Drehu is linked with increased VOT. Additionally, a positive attitude towards French shows a stronger correlation with devoicing of /g/ than a positive attitude towards Drehu. In contrast, male speakers show greater devoicing in relation to more positive language attitudes towards Drehu. Considering that French canonically uses lead voicing in voiced stops and short lag VOT for voiceless stops, this suggests speakers could be marking a stronger difference between Drehu and French. We speculate that aspiration, which is present in the neighbouring language Nengone, could be viewed as a more 'Kanak' feature whereas voicing could mark a more 'European' feature. It remains to be seen how speakers produce these stop series in French and how this aligns with their language attitudes. Further comparison to older speakers will be necessary to confirm our hypothesis of a change in progress. Finally, a more nuanced approach that considers social factors beyond sex will be of relevance too.

6. REFERENCES

[1] T. Crowley, J. Lynch, and M. Ross, *The Oceanic languages*. Routledge, 2011.

[2] D. T. Tryon, *Dehu grammar*. Australian National University, 1968.

[3] ——, *Nengone grammar*, ser. Pacific Linguistics, Series B. Canberra: Australian National University, 1967, vol. 6.

[4] ——, *Iai Grammar*, ser. Pacific Linguistics, Series B. Canberra: Australian National University, 1968, vol. 8.

[5] F. Ozanne-Rivierre, *Le iaai: langue mélanésienne d'Ouvéa, Nouvelle-Calédonie: phonologie, morphologie, esquisse syntaxique*. Peeters Publishers, 1976, vol. 20.

[6] J. Monnin, "Influence de la langue ambiante sur l'acquisition phonologique: une comparaison du français et du drehu," Ph.D. dissertation, Université de Grenoble; Université de Nouvelle Calédonie, 2010.

[7] I. Maddieson and V. B. Anderson, "Phonetic structures of iaai," *UCLA Working Papers in Phonetics*, vol. 87, pp. 163–182, 1994.

[8] C. Torres, J. Fletcher, and G. Wigglesworth, "Fundamental frequency and regional variation in Lifou French," *Language and Speech*, 2020.

[9] ——, "Investigating word prominence in Drehu," in *Proceedings of the 17th Australasian International Speech Science and Technology Conference*, 2018, pp. 141–144.

[10] C. Torres, "Pitch range modulations in an edge-marking language," *Proceedings of Speech Prosody 2022*, pp. 832–836, 2022.

[11] C. Torres and J. Fletcher, "The alignment of F0 tonal targets under changes in speech rate in Drehu," *The Journal of the Acoustical Society of America*, vol. 147, no. 4, pp. 2947–2958, 2020.

[12] C. Moyse-Faurie, *Le drehu, langue de Lifou (Iles Loyauté). Phonologie, morphologie, syntaxe*. Langues et Cultures du Pacifique Ivry, 1983.

[13] M.-H. Lenormand, "La phonologie du mot en lifou (îles loyalty)," *Journal de la Société des Océanistes*, vol. 10, no. 10, pp. 91–109, 1954.

[14] C. Torres and J. Fletcher, "Phrase-level and edge marking in Drehu," *Glossa: a journal of general linguistics*, vol. 7, no. 1, 2022.

[15] G. Zellou, C. DiCanio, A. Pycha, and A. C. L. Yu, "Introduction to sound change in endangered or small speech communities," *Linguistics Vanguard*, vol. 8, no. s5, pp. 491–497, 2022. [Online]. Available: https://doi.org/10.1515/lingvan-2021-0095

[16] S. Bearune, "L'expression linguistique de l'espace en nengone (Nouvelle-Calédonie)," Ph.D. dissertation, Paris, INALCO, 2012.

[17] C. Fougeron and C. L. Smith, "Illustration of the ipa: French," *Journal of the International Phonetic Association*, vol. 23, pp. 73–76, 1993.

[18] T. M. Nearey and B. L. Rochet, "Effects of place of articulation and vowel context on vot production and perception for French and English stops," *Journal of the International Phonetic Association*, vol. 24, no. 1, pp. 1–18, 1994.

[19] L. M. Gertken, M. Amengual, and D. Birdsong, "Assessing language dominance with the Bilingual Language Profile," *Measuring L2 proficiency: Perspectives from SLA*, pp. 208–225, 2014.

[20] T. Kisler, U. Reichel, and F. Schiel, "Multilingual processing of speech via web services," *Computer Speech & Language*, vol. 45, pp. 326–347, 2017.

[21] M. Sonderegger and J. Keshet, "Automatic measurement of voice onset time using discriminative structured prediction," *The Journal of the Acoustical Society of America*, vol. 132, no. 6, pp. 3965–3979, 2012.

[22] P. Boersma and D. Weenink, "Praat: doing phonetics by computer (version 6.1.52)[computer program]," 2017.

[23] P.-C. BÃ¼rkner, "Advanced Bayesian Multilevel Modeling with the R Package brms," *The R Journal*, vol. 10, no. 1, pp. 395–411, 2018. [Online]. Available: https://doi.org/10.32614/RJ-2018-017

[24] D. Makowski, M. S. Ben-Shachar, and D. Lüdecke, "bayestestr: Describing effects and their uncertainty, existence and significance within the bayesian framework," *Journal of Open Source Software*, vol. 4, no. 40, p. 1541, 2019.

[25] R. Lenth, "emmeans: Estimated marginal means, aka least-squares means. R package version 1.7.1-1," 2021.

[26] H. M. Hanson, *Glottal characteristics of female speakers*. Harvard University, 1995.

[27] A. Yamauchi, H. Yokonishi, H. Imagawa, K.-I. Sakakibara, T. Nito, N. Tayama, and T. Yamasoba, "Age-and gender-related difference of vocal fold vibration and glottal configuration in normal speakers: analysis with glottal area waveform," *Journal of Voice*, vol. 28, no. 5, pp. 525–531, 2014.

[28] J. J. Ohala, "Aerodynamics of phonology," in *Proceedings of the Seoul International Conference on Linguistics*, vol. 92. Linguistic Society of Korea Seoul, 1997, p. 97.

[29] T. Cho and P. Ladefoged, "Variation and universals in VOT: evidence from 18 languages," *Journal of phonetics*, vol. 27, no. 2, pp. 207–229, 1999.

[30] J. Kuang and A. Cui, "Relative cue weighting in production and perception of an ongoing sound change in southern yi," *Journal of Phonetics*, vol. 71, pp. 194–214, 2018.

[31] L. Lisker and A. S. Abramson, "A cross-language study of voicing in initial stops: Acoustical measurements," *Word*, vol. 20, no. 3, pp. 384–422, 1964.

[32] W. Labov, "The intersection of sex and social class in the course of linguistic change," *Language variation and change*, vol. 2, no. 2, pp. 205–254, 1990.