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Is it all about race?: A Cross-examination of /s/ in a Multilingual (Nigerian) Context

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Abstract

Previous studies on /s/ variation have examined how /s/ production functions as an indexical marker, particularly in relation to gender and race. These studies primarily focus on Western contexts (e.g., North America) to explain that /s/ can signal gendered personas and racialized social meanings. However, in a multilingual context like Nigeria, /s/ has not been explored to identify motivation(s) for /s/ variation.

This study, therefore, examines /s/ production in Nigerian English (NigE), focusing on the factors that condition /s/ variation. The study samples 4,056 tokens of /s/ from the ICE-NigE and they are analyzed using center of gravity, zero crossings, duration, and skewness to explain /s/ frontness or backness.

The results reveal that ethnicity and year of birth influence /s/ variation. The younger speakers produce fronted /s/, and older speakers realize a more retracted /s/. While /s/ is more fronted among the Igbo NigE speakers, it is more retracted among Yoruba and Hausa NigE speakers, and the absence of gender difference may highlight the importance of ethnicity rather than gender in a multilingual context.

Index Terms: /s/-production, Nigerian English, acoustic cues, ethnicity, multilingual context, spectral change

1. Introduction

The study of linguistic variables, such as /s/ production, has traditionally focused on examining how linguistic and sociolinguistic factors condition phoneme realization. These factors provide insights into the production of /s/. For example, /s/ production has been investigated from gender, race, and social identity [1, 2, 3]. These studies have highlighted how /s/ production indexes speaker's identity and social constructs (e.g., gay-sounding or 'feminine' speech), but these analyses have frequently been framed within monolingual or racialized contexts, such as in North America and Europe [4]. In contrast, this study shifts the focus to a multilingual context, where phenotype and skin color are not the major marker of identity, and linguistic variations are motivated by sociocultural factors [5].

Research in racialized contexts often indexes /s/ variation (as frontness or backness) with gendered or racial performance. These studies explore /s/ as an index of queer identity in San Francisco, exemplifying its role in the construction of identities beyond normative gender binaries [6, 7]. Other studies investigate /s/-fronting in Southeast England, linking it to social stratification and gender identity [8]; associate /s / with transgender and queer identities, highlighting its role in stylistic bricolage and the negotiation of gender [9, 4]. While these studies explain /s/ as a social identity construct, they remain constrained by the racial and gendered frameworks within which they are situated.

In a linguistically diverse country such as Nigeria, with more than 200 million speakers [10], racism plays an inconsequential role in /s/ productions [5]. Instead, factors such as ethnicity, multilingualism, level of education attainment, and speaker's professions motivate variation of sound production (e.g., NURSE vowels) [11, 12]. Since no available sociophonetic study explores /s/ variation in a multilingual Nigerian context, we aim to examine the motivation for /s/ variation in NigE to augment previous studies on /s/ and highlight primary determinants of /s/ in a linguistically diverse ecology. The result of this study is important for our understanding of the /s/ variable in different linguistic contexts.

Unlike monolingual or racially stratified contexts, /s/ production in NigE may reveal the influence of ethnicity and other factors following the results of NURSE vowel realization in [11, 12]. These may explain a phonetic variation of /s/ without NigE speakers doing/performing gender or ethnicity [13, 14, 15] that is similar to performativity in Western contexts [6]; instead, the NigE speakers produce /s/ naturally, however, speaker's ethnicity differentiates one from another. Despite the naturalness, the difference by ethnicity is perceptually evident. Hence, investigating /s/ in NigE offers another panorama to /s/ variation, driven by differences in ethnic groups (and speaker's geographical location - region) in a multilingual context rather than in the Western contexts that is heavily available in the race literature.

Moving beyond the scope of race-centric investigation of /s/, we aim to examine the potential influence of multilingual ecology on /s/ variation and explain the intersectionality of ethnicity, gender, and age factors that condition /s/ production. The findings will augment our knowledge of /s/ and highlight the importance of examining the phenomenon from linguistically diverse contexts.

2. Methodology

2.1. Procedure for data elicitation

To analyze /s/ production, we selected 42 (20 males, 22 females) high-quality audio files from ICE-NigE with minimal background noise, echoes, speech interruption, or multiple speakers simultaneously. The /s/ was produced by Igbo, Hausa, and Yoruba NE speakers. The metadata of these speakers in the ICE-NigE included the speaker's ethnicity, gender (female as a baseline), and year of birth between 1950s and 2000s ($\bar{x}$ = 47, SD = 13.79). The audio files and transcriptions were force-aligned using WebMAUS Basic [16], which generated annotated TextGrids with segment boundaries. These were manually aligned where necessary in Praat [17] using auditory and spectrogram cues to mark /s/ onset and offset, and a modified Praat script extracted CoG, duration, skewness, and number of zero

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crossing in an interval, which were analyzed in R [18].

In addition, to collect CoG measurements, all tokens were band-passed filtered to a 1,000-22,050 Hz bandwidth to filter out frequencies too low to be in the range of /s/ frication. Following the previous work [6, 1, 19], the duration was log-transformed. In addition, we excluded /s/ tokens immediately adjacent to another sibilant sound, given the ambiguity of delimiting boundaries between adjacent sibilants. We restricted the analysis to tokens from different genres (e.g., broadcast talks, unscripted speeches, lessons, non-broadcast talks, conversations, and demonstrations) of NigE in International Corpus of English-Nigeria (ICE-NigE); tokens during the advertisement, interruption, and background noise were excluded. In total, we analyzed 4,056 tokens of /s/ after the data cleaning across the three major groups: Hausa, Igbo, and Yoruba NigE speakers.

2.2. Method of Analysis

This study analyzes CoG, skewness, and zero crossing for /s/ production:

CoG:

- *Fronted /s/:* Higher CoG values indicate concentrated high-frequency energy due to anterior tongue positioning.
- *Retracted/backed /s/:* Lower CoG values reflect energy in lower frequencies due to posterior articulation.

Zero crossing:

- High zero crossing in the first 30 milliseconds (ms) indicates greater turbulence and rapid onset of /s/ production.
- High zero-crossing counts across the interval reflect more turbulence and high-frequency energy, typical of fronted /s/ articulations.
- Low zero-crossing counts suggest reduced turbulence, which may indicate a more retracted or backed /s/.
- Normalized zero-crossing rates (zero crossings * 10 / interval duration) help compare turbulence levels across speakers or speaking rates.

Duration

- Duration is important in differentiating /s/ frontness from backness. Longer /s/ duration is often associated with more retracted (backed) /s/ production, and /s/ with shorter duration is fronted.

Skewness:

- Positive skewness indicates energy concentrated in higher frequencies (fronted /s/).
- Negative skewness indicates energy concentrated in lower frequencies (backed /s/).
- Near-zero skewness suggests symmetrical energy distribution, possibly reflecting central articulation.

Skewness estimates (underlying) differences in the spectral energy distribution that may not be obvious in the CoG. For example, two /s/-realizations might have similar CoG values but differ in skewness. The differences reflect how the spectral energy is distributed for high or low frequencies. Combining skewness with CoG helps us understand how the production of /s/ varies in terms of frontness and backness. This makes skewness an important complementary acoustic cue. As we integrate these cues, our study describes the status of /s/ in multilingual NigE.

2.3. Statistical Methods

Four statistical models were used to analyze /s/ data:

1. Within-NigE models for Igbo, Yoruba, and Hausa NigE speakers, respectively.
2. An across-ethnicity model including all three groups.

Each model incorporated gender, birth year, and segment duration as fixed effects for CoG, zero crossings, and skewness. Speaker and phonological environment (preceding and following) were treated as random effects. The best fit model for within-NigE included these fixed and random effects (R^2 = 84%). The across-ethnicity model also included speaker ethnicity as a fixed effect. Mixed-effects linear regression was performed in R Studio using the `lme4` package [18]. Interactions between fixed effects were tested, and only statistically significant interactions were included in the final models. This approach estimates the interaction between the linguistic and sociocultural factors that condition /s/ production.

3. Analysis

3.1. CoG

The analysis of CoG reveals the effects of gender, year of birth, and segment duration.

3.1.1. Igbo

For Igbo speakers, the fixed effects model revealed a significant effect of year of birth, $\beta = 152.0$, $SE = 31.4$, $t(8.67) = 4.83$, $p = .001$, indicating that CoG increases with year of birth. Duration also had a significant positive effect, $\beta = 186.3$, $SE = 53.9$, $t(839) = 3.45$, $p < .001$. The effect of gender was marginal, $\beta = 189$, $SE = 929.0$, $t(9.52) = 2.04$, $p = .06$. The random effect results showed more variation in / s / production among Igbo speakers ($SD = 1088.1$) than linguistic factors: preceding segments ($SD = 247.1$), and following segments ($SD = 320.9$)

3.1.2. Yoruba

For Yoruba speakers, duration was a significant predictor, $\beta = 329.7$, $SE = 59.9$, $t(945) = 5.49$, $p < .001$. Similarly, year of birth was significant ($\beta = 135$, $SE = 47.6$, $t(7.07) = 2.83$, $p = .02$). However, there was no effect of gender in CoG (p ¿ .05). The random effect results revealed more variability among Yoruba speakers ($SD = 1555.1$ than the preceding ($SD = 237.8$) and the following ($SD = 174$) segment.

3.1.3. Hausa

For Hausa speakers, duration and gender significantly influenced CoG [duration: $\beta = 542.7$, $SE = 65.2$, $t(1059.6) = 8.31$, $p < .001$; gender: $\beta = -2756$, $SE = 808.14$, $t(544) = -3.41$, $p < .001$]. Year of birth (p = .58) was not significant. The random effect results showed similar pattern with other groups.

3.1.4. Across-Ethnicity

When modeling across ethnicities, a significant interaction between year of birth and duration was evident, $\beta = 595$, $SE = 254$, $t(284.3) = 2.34$, $p = .001$. Ethnic group differences were not statistically significant (p = .98), however, the estimate showed that Igbo speakers have higher CoG values than other groups with a difference of 600Hz (see Figure 1)

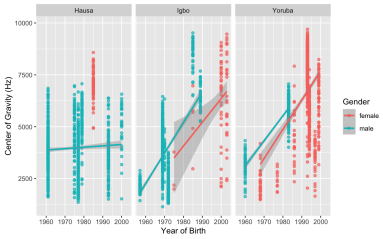

Figure 1: */s/ center of gravity by ethnicity and year of birth.*

3.2. Zero crossing

3.2.1. Zero Crossings in the First 30ms

The mixed-effects model for zero crossings in the first 30ms revealed significant effects of year of birth for Igbo speakers. Year of birth positively influenced zero crossings, $\beta = 5.15$, $SE = 1.33$, $t(7.10) = 3.93$, $p < .05$, indicating that younger speakers produce more turbulent /s/ onsets. Gender was not significant. Random effects showed variability by speaker ($SD = 41.9$), and phonological context ($SD = 13.2$ for following segments and $SD = 14.55$ for preceding segments).

For Yoruba speakers, duration significantly influenced zero crossings, $\beta = -27.25$, $SE = 7.73$, $t(928.07) = -3.52$, $p < .001$, indicating that longer segments reduce turbulence during the onset. Gender and year of birth did not yield significant effects. For Hausa, only gender was significant $\beta = -163.7$, $SE = 33.8$, $t(6.69) = -4.83$, $p < .05$. The presence of spectral energy in the first 30 ms differs by gender among Hausas.

3.2.2. Interval zero crossings

For Igbo speakers, the model indicated that duration was a significant predictor, $\beta = 1591$, $SE = 123.5$, $t(848.7) = 12.88$, $p < .001$, showing that longer /s/ production has more turbulence. For Yoruba speakers, similar trends were observed, with segment duration significantly influencing zero crossings, $\beta = 1136.2$, $SE = 26.85$, $t(945.5) = 42.30$, $p < .001$. No significant effects were found for gender or year of birth. Among Hausa speakers, there were gender $\beta = 481.34$, $SE = 129.18$, $t(589) = -3.72$, $p < .001$ and duration $\beta = 473.88$, $SE = 13.6$, $t(1048.7) = 34.5$, $p < .001$ effects.

3.2.3. Normalized Zero Crossings

In the normalized zero-crossing model, year of birth positively affected normalized zero crossings for Igbo speakers, $\beta = 2.40$, $SE = 0.63$, $t(7.70) = 3.78$, $p = .016$, while segment duration remained highly significant, $\beta = 7.39$, $SE = 1.20$, $t(841.7) = 6.12$, $p < .001$. The effect of gender was marginal $\beta = 38.97$, $SE = 18.54$, $t(8.32) = 2.10$, $p = .06$ with random effects of speakers ($SD = 30.27$) and phonological context ($SD = 9.63$ for following segments and $SD = 5.56$ for preceding segments).

Among Yoruba speakers, duration was a significant predictor, $\beta = 15.43$, $SE = 1.80$, $t(945) = 8.53$, $p < .001$, with a marginal effect for year of birth (p = 0.06), but gender did not show any effect. Meanwhile, gender and duration were significant for Hausa speakers [gender $\beta = -55.74$, $SE = 15.63$, $t(5.45) = -3.56$, $p < .01$; duration: $\beta = 12.46$, $SE = 1.21$, $t(1054) = 10.25$, $p < .001$]

3.2.4. Across Ethnicities

When modeling across ethnicities, year of birth significantly predicted normalized zero crossings, $\beta = 1.37$, $SE = 0.62$, $t(18.99) = 2.21$, $p = .039$, indicating that younger speakers produce more turbulent /s/ sound. Duration was also a significant predictor, $\beta = 14.06$, $SE = 0.75$, $t(3386.63) = 18.71$, $p < .001$, but ethnicities were not significant.

3.3. Skewness

3.3.1. Igbo

The model for skewness revealed a significant negative effect of year of birth, $\beta = -0.13$, $SE = 0.04$, $t(9.35) = --2.72$, $p = .02$, indicating that younger Igbo speakers produce /s/ with less asymmetry in spectral energy distribution. Duration also significantly affected skewness, $\beta = -0.34$, $SE = 0.15$, $t(818.01) = -2.27$, $p < .02$. Gender did not significantly influence skewness in this group. Random effects showed variability attributable to speakers ($SD = 1.48$) and phonological context ($SD = 1.00$ for preceding segments and $SD = 0.38$ for following segments.

3.3.2. Yoruba

For Yoruba speakers, year of birth significantly influenced skewness, $\beta = -0.06$, $SE = 0.01$, $t(739) = -3.66$, $p < .01$. Neither gender $\beta = -.71$, $SE = 0.55$, $t(7.79) = -1.29$, $p = .23$) nor duration ($\beta = -.09$, $SE = .05$, $t(950.5) = -1.64$, $p = .09$) significantly affected skewness. Random effects revealed variability primarily attributable to speakers ($SD = 0.79$) and phonological context ($SD = 0.28$ for preceding segments and $SD = 0.08$ for following segments).

3.3.3. Hausa

The model for Hausa speakers indicated a significant negative effect of duration, $\beta = -63$, $SE = 8.56$, $t(104) = -7.32$, $p < .001$, reflecting reduced skewness for longer segments. Neither year of birth ($\beta = -.003$, $SE = 0.02$, $t(5.19) = -0.15$, $p = .885$) nor gender was significant with random effects: speakers ($SD = .77$), preceding segment ($SD = .58$, and $SD = .15$ for following segments).

3.3.4. Across Ethnicities

There was a significant negative effect of year of birth ($p < .001$). The younger speakers produce /s/ with less asymmetry in spectral energy distribution, reflecting a potential shift toward more centralized articulations over time. Similarly, duration is a strong predictor ($p < 0.001$), with longer segments associated with reduced skewness. However, ethnicity did not significantly influence skewness.

4. Discussion and Conclusion

The analysis of /s/ production in NE shows how linguistic (preceding and following segments) and sociolinguistic (ethnicity, age, and gender) factors influence the realization of /s/ among Nigerians. The results align with [4, 6] that social and linguistic factors affect /s/; however, the analysis offers insights into /s/ beyond racially stratified or monolingual settings. For example, across the three groups, /s/ duration consistently emerged as a significant factor in influencing spectral measures. While gender effects were generally limited, age showed significance mainly among Igbo speakers, showing that /s/ frontness as a

social marker may be more age-dependent. The phonological context and individual differences also affect /s/. When /s/ is followed by high-front vowels and diphthongs or preceded by front vowels and velar, there is evidence of /s/ frontness. However, /s/ becomes more retracted when it is followed by velars or when low back vowels, diphthongs, and voiced stops precede it. These patterns support the effects of co-articulation, and the speaker's influence reveals more variability.

CoG revealed significant effects of year of birth and duration, with younger Igbo speakers producing /s/ with frontness (higher CoG). The significant relationship between the year of birth and higher CoG suggests an ongoing sound change in a multilingual speech community. For example, younger Igbo speakers fronted /s/, indicating age differences in articulation patterns. Also, the results show that the production of /s/ differs across ethnicities [Hausa: 1700 $\geq$ 7800Hz; Igbo: 1200 $\geq$ 9700Hz; Yoruba: 1500 $\geq$ 8300Hz]. These speakers differentiated their /s/ production to index ethnic identity. Since a similar pattern is not evident among Hausa younger speakers, the frontness shows a regionally specific linguistic evolution in the Igbo-speaking community, which supports [4] and [19], that associate /s/-frontness with social identity markers. In NigE, these articulatory shifts index multilingual ecology rather than the gendered or racialized frameworks seen in Western contexts. The absence of significant gender effects among Yoruba speakers reinforces the unique ecology of NigE, where ethnicity might be more predictive than gender.

Also, previous studies [4] and [19] have shown significant gender differences, with women generally producing a more fronted /s/ and men producing a more backed or retracted /s/. However, in NigE, these frontness/backness patterns are not consistently influenced by gender, and the statistical models for within and across groups show different behavior and determinant of /s/ production.

In zero crossing, younger Igbo NigE speakers produced more turbulent /s/ at the onset, as evidenced by higher zero crossings in the first 30 ms of /s/ production. This pattern suggests increased articulatory precision and a trend toward fronted /s/ production. This is similar to [4, 1] that turbulence reflects articulatory configurations. For Yoruba and Hausa speakers, longer segment durations correlated with smaller turbulence, showing articulatory stability. These findings emphasize the role of temporal factors in shaping turbulence and support [1]'s argument that acoustic variability explains articulation.

In NE, birth year significantly influences zero crossing, revealing that younger speakers produce more spectral energy in the first 30ms. This shows an increased articulation with a higher fundamental frequency that indexes fronted /s/. In addition, gender shows a marginal effect, with male speakers producing slightly fewer zero crossings than females, which corroborates previous findings [19] and [4] that women often exhibit more fronted /s/. However, zero crossing in the first 30ms does not significantly differ by ethnicity.

The zero crossing interval supports the result of the zero crossing at 30 ms. The results show that gender plays a significant role in the articulation of /s/ production especially among Hausa speakers, with male speakers producing longer zero crossing intervals compared to females, indicating differences in the spectral characteristics of /s/. The significant interaction between gender and duration further suggests that male speakers may maintain more stable articulatory patterns over varying durations, while female speakers show more variation with increased duration. This supports the explanation that women often produce higher-frequency, fronted /s/ sounds while men produce lower-frequency, backed articulations. However, ethnicity and year of birth are not significantly correlated. When we further examine the relationship between Hausa and Igbo NigE speakers, the difference shows that /s/ frontness is based on zero-crossing counts. Since high zero-crossing counts reflect more turbulence and higher-frequency energy, typically associated with fronted /s/ articulations, the positive estimate for Igbo and Hausa suggests that Igbo and Hausa NigE speakers produce higher zero-crossing intervals than Yoruba NigE speakers. This effect is statistically significant, as Igbo NigE speakers exhibit more fronted /s/ articulations than Hausa speakers. However, the effect Yoruba speakers is non-significant.

The results for skewness show a generational shift in the realization of /s/, with younger speakers producing /s/ with less asymmetry in spectral energy distribution among Igbo and Yoruba. This pattern indicates a shift toward more centralized articulation over time, as younger speakers exhibit lower skewness values. The decrease in skewness suggests that /s/ production tends to be more balanced, with energy distributed more symmetrically across the frequency spectrum. This generational trend reflects broader linguistic shifts influenced by /s/ changing among Nigerians. The implication of the change possibly aligns with the effect of age.

Meanwhile, the duration of /s/ affects skewness. The longer /s/ production is associated with reduced skewness and suggests an articulatory move toward backness as /s/ duration increases. This relationship indicates that /s/ production and duration are strongly correlated, where delayed/prolonged productions signal /s/ backness. The absence of a significant effect on ethnicity suggests that skewness variation is not ethnically marked. Instead, duration and age influence spectral distribution in /s/ production. This finding shows that skewness alone may not differentiate frontness or backness in /s/ production by ethnicity in a linguistically diverse context. Otherwise, other social factors, such as the educational level of the speaker and the social class, which the present study does not explore may be necessary in describing spectral differences in NigE.

Out of the three measurements of /s/ for this study, CoG and zero crossing show /s/ frontness among Hausa and Igbo NigE speakers, while Yoruba NigE speakers produce more central or towards /s/ backness. On the other hand, /s/ frontness is indexed by race (whiteness or blackness) and gender in Western culture; in NigE, it may be primarily marked by the speaker's ethnicity and age. The absence of strong gender effects and the peculiar behavior of /s/ within ethnic group and age reveal the uniqueness of multilingual contexts. For example, Hausa and Igbo NigE speakers exhibited greater variability in CoG and zero crossing, showcasing the effect of linguistic and sociolinguistic factors. In contrast, Yoruba speakers show more stable patterns (or /s/ backness), suggesting that ethnicity conditions variation of /s/ in multilingual ecology. The intersectionality of ethnicity, gender, and age influences shows broader sociolinguistic factors that ethnicity is a primary factor in the frontness of /s/ (in NigE) rather than gender and race as obtained in a racially stratified monolingual Western context.

This study provides some evidence that /s/ production in NigE is conditioned by both ethnicity and age, with each ethnic group revealing different patterns. Also, age emerged as a consistent predictor across groups, showing a generational shift in /s/ production. These findings extend our knowledge of /s/ variable beyond Western contexts. In the future, I will examine /s/ production in sub-varieties of NigE to identify L1 influence and compare it to /s/ production in L2, which may explain how transfer and restructuring contribute to /s/ variation in NigE.

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