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Acoustic Realisation of the Central Vowels /Ə/ and /ɜː/ in Received Pronunciation and Educated Nigerian English: A Comparative Formant, Amplitude and Frequency Analysis

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Abstract

This present study acoustically compares two central vowels of English, that is, the mid-central short vowel /ə/ popularly known as schwa, and the mid-central long vowel /ɜː/ which linguists refer to as NURSE sound, as realised in Received Pronunciation (RP) and Educated Nigerian English (NigE). Analysis centres on realisations of the two centralised mid-vowels (short /ə/ and long /ɜː/) in the chosen corpora. Spectrographic analysis of formants in the target words: brother, butter, discussion, bird, early and journal estimates differences in first and second formant frequencies, amplitude, temporal realisation and overall spectral shape. Fifty speakers (25 RP reference speakers and 25 educated Nigerian English speakers) produced the words in word-list and sentence reading frames; data underwent Praat spectrographic analysis. Results show that RP speakers maintain a centralised /ɜː/ with rather low F1 and intermediate F2 values, and a highly reduced schwa can also be observed. NigE speakers consistently de-centralised, replaced or substituted both target vowels, producing a substantially elevated mean /ɜː/ F1 by 164 Hz and a 136 Hz increase for centralised schwa. Evidently, the duration dissimilarity between

short centralised vowels is considerably narrower in the NigE variety. The differences in this duration difference influence intelligibility and shape the description of Nigerian English as an endonormative variety. In the mixed-method research design, depict divergence through quantitative formant frequency data, and through qualitative listening and spectrographic analysis of amplitude, duration and overall shape. This method reveals the array of differences, in the centralised short-vowel realizations of the two English dialects.

Keywords: Central vowels, formants, Received Pronunciation, Educated Nigerian English, Praat Spectrographic analysis

1.1 Introduction

The central vowels are an unpredictable area of the English vowel system. In RP they serve both lexical and prosodic roles: /ɜː/ distinguishes minimal pairs such as bird–bard, while /ə/ realizes the bulk of unstressed syllables and drives the characteristic stress-timed rhythm of the variety. The schwa sound /ə/ is used in most of the syllables and gives RP its famous way of timing and rhythm. In Nigerian English the central vowels are known to be replaced, neutralized and/or changed due to the influence of the native vowel systems which do not contain central vowels. There is a lot of listening information on this, however, there is little instrumental information on the differences in F1, F2 and amplitude and frequency between the two lexical sets. This paper gives a look into this, by providing sound measurements of the six words, brother, butter, discussion (SCHWA) bird, early and journal(NURSE/ (reversed epsilon)). This shows how different RP and Educated NigE in their articulations.

The meaning or importance of these two vowels is very high: /ɜː/ is part of minimal pairs while /ə/ makes up a large part of the vowel sounds in spoken language and helps show where the stress is and how the rhythm works. Earlier studies have found reference values for /ɜː/ in standard pronunciation (usually F1 is about 500 to 600 Hz F2 is about 1400 to 1600 Hz for adult male speakers) and have recorded how the schwa changes depending on the situation but there is still not enough specific information for Educated NigE. By looking at the six chosen words and by using formant measurements in the middle of the sounds along with duration and loudness measurements this study gives numbers that can help both theories, about how second language speakers learn vowels and real uses in teaching pronunciation and speech technology.

1.2 Background of the Study

English was introduced to Nigeria through colonial encounters, and since then it has taken a form that is more settled for native communication, with tens of millions of speakers. Compared to RP, the realization of the post-vocalic /r/ is reduced in Nigerian English varieties, with some phonological restructuring in this area. The languages of Nigeria are also primarily CV(C) in structure, so languages such as Yoruba, Igbo and Hausa, with either five- or seven-vowel systems have previously been observed to exhibit peripheral-central vowel realisations. This results in /ɜː/ being realised as [ɛ], [a], [ɔ] or [e] as opposed to centralised [ɜː], while schwa is often deleted. Earlier impressionistic studies of Nigerian English are found in (Jowitt, 2000) and (Simo Bobda, 2000). The last two decades have seen an increase in studies using (Jamakovic & Fuchs, 2019), (Oladipupo, 2014) and (Adeyemi, 2024) formant analyses,

with only a few of them addressing specifically the differences between the two central vowels in comparable materials and speakers. The current study aims to bridge the gap and fall under the scope of acoustic phonetics, World Englishes and second language speech.

1.3 Statement of the Problem

In terms of functions these two central vowel /ə/ and /ɜː/ are given their rightful place in pronunciations, but the exact acoustic details that set them apart in RP and NigE are still not distinctively clear. This is particularly true for the formant trajectories of /ə/ and /ɜː/, the amplitude envelopes of /ə/ and /ɜː/ and the duration of /ə/ and /ɜː/. No single planned study has measured these details while using both native-reference speakers and educated Nigerian speakers. Many earlier studies either looked at all monophthongs together. Mostly listened and wrote down sounds. Because of this, teachers, speech technologists and people who study how well speech is understood do not have acoustic numbers for the middle vowel area in NigE. Recent work on NigE vowels by Jamakovic & Fuchs (2019); Amoniyan (2025) and Oladipupo & Akinola (2022) looked at vowels or focused on the very high and very low ones. No study has given an instrument-based comparison of /ə/ and /ɜː/. No study has reported the F1 and F2 values the spread of those values and the amplitude and frequency data, for the exact words ‘’brother, butter, discussion, bird, early and journal’’. The present study fills this gap by combining quantitative formant statistics with qualitative spectrographic commentary on exactly those items.

1.4 Aim and Objectives of the Study

The aim of this study is to give an detailed acoustic description of the central vowels /ə/ and /ɜː/ in Received Pronunciation and Educated Nigerian English. It also seeks to measure how apart these two varieties are in terms of pronunciation.

1.5 Objectives of the Study

1. To. Compare the average F1, F2, duration and amplitude values of the schwa sound /ə/ in the words brother, butter and discussion as spoken by speakers of Received Pronunciation and Educated Nigerian English.

2. To. Compare the same acoustic features for the NURSE vowel /ɜː/ in the words bird, early and journal.

3. To find out how central or peripheral the two vowels are in Nigerian English when compared to the standards of Received Pronunciation. This includes looking at how L1 influence and the way wordsre written in English affect the pronunciation patterns.

1.6 Research Questions

1. Are there any significant differences in the F1, F2, duration and amplitude of the schwa /ə/ between speakers of Received Pronunciation and Educated Nigerian English in the target words?

2. What are the corresponding differences for the NURSE vowel /ɜː/ in the context?

3. To what degree do the acoustic patterns observed in Nigerian English support the idea that Nigerian English changes the central area of the vowel space because of first language influence and the pressure, from written English?

2.1 Literature Review

Acoustic studies continue to provide robust values for RP monophthongals and their position. Hawkins and Midgley (2005) report F1 values for RP /ɜː/ clustering around 500-600 Hz and F2 around 1400-1600 Hz for adult male speakers, with schwa demonstrating greater contextual variability and generally lower intensity. Subsequent studies have found the relative stability of the RP NURSE vowel even through progressive fronting of other back vowels (Ferragne & Pellegrino, 2010).

In the Nigerian context, Jamakovic and Fuchs (2019) showed that educated Southern NigE speakers operate a reduced seven-monophthong system where the NURSE vowel is no longer maintained as a separate central quality but rather realised on a written basis as [ɛ], [a] or [ɔ]. Their Lobanov-normalised formant plots show NigE tokens lying well outside the RP central region. Equally, results in Bello et al (2020) report mean F1 values for NigE /ɜː/ around 705 Hz with F2 values of approximately 1508, collapsing phonetic distances between NURSE, STRUT and TRAP. Further empirical confirmation comes from Oladipupo's several studies (Oladipupo, 2014; Oladipupo & Akinola, 2022) which highlight the rare occurrence of schwa reduction in unstressed syllables for most NigE speakers, a fact corroborated by a pilot acoustic investigation of Native English Speakers in Nigeria (Oladipupo, 2025. Adeyemi (2024) designed a variationist experiment including Hausa, Igbo and Yoruba speakers which confirmed that all of these groups substitute the three English central qualities with their L1-closest equivalents, choice guided above all by spelling patterns.

Gut (2008) provides a broad phonological overview of NEE noting that it features a significantly reduced vowel inventory compared to RP, including central vowels among the most commonly replaced categories. She notes the complete lack of mid-central quality in any major Nigerian language results in systematic replacement of /ɜː/ and /ə/ with periphery realisation, even in more formal educated speech. Extending the question is Amoniyan (2025) who examines dynamic change as opposed to the static mid-point of formant values for Western Nigerian English, proving that trajectories further confuse the identification of any central region and various factors modulate the impact.

The convergence of the present results establishes the central area as a space of divergence and leaves an item-specific comparison of formant and amplitude values of the six words addressed here as a missing piece. It is directly on this issue that this study provides further evidence by measuring F1, F2, duration and amplitude values for precisely these dictionary items: brother, butter, discussion, bird, early and journal as earlier investigations of either descriptive type or more wide-ranging nature could not.

2.2 Theoretical Framework

The study is framed by Flege's Speech Learning Model (SLM) and its revised version (SLM-r). Predictions are made based on the hypothesis that L2 phoneme(s) without corresponding items in the L1

inventory will be difficult to delineate and will therefore be assimilated into existing categories, realising measurable acoustic divergence from native norms. Given the absence of a stable mid-central in any of the major Nigerian languages, the framework accounts exactly for the decentralisation and substitution tendencies reported in the literature. Labovian variationist principles act as a supplemental framework considering that orthographic inventory and sociolinguistic influences further condition variation in the speech community.

3.1 Research Methodology

A mixed method design combining quantitative acoustic measurements with qualitative spectrographic and auditory analysis was employed. The participant pool comprised 50 individuals - 25 RP-oriented reference speakers (British English natives or near-natives residing in Nigeria or the UK, balanced for gender), and 25 educated Nigerians (university graduate/postgraduate level, balanced across Hausa, Igbo and Yoruba L1 backgrounds and gender). Participants read a randomised word list with the six target items embedded in carrier sentences and a brief reading passage. Recordings were made in sound isolation booths using a high-quality headset microphone at 44.1 kHz sampling rate.

Acoustic analyses were conducted in Praat (Boersma & Weenink, 2023). For each token, the steady-state portion of the vowel was manually sliced; F1 and F2 were measured at the temporal midpoint, duration extracted, and root-mean-square amplitude calculated. Normalised (Lobanov) formant values were also obtained to account for individual anatomical variation. Independent-samples t-tests and mixed-effects linear models were applied to assess intergroup variability. Spectrograms of exemplar tokens of brother, butter, discussion, bird, early and journal were qualitatively analysed for formant-trajectory morphology, bandwidth and energy dispersion. Ethical approval and informed consent were obtained from all participants prior to data collection.

4.1 Findings and Discussion

Spectrographic inspection of the tokens of RP reveals a classic central-vowel behaviour. In bird, early and journal the NURSE vowel is a steady, mid-height, central resonance, with F1 typically 520-580 Hz and F2 1450-1550 Hz and amplitude relatively high and sustained to account for its long duration (approximately 180-220 ms). For the occurrence of schwa in brother, butter and discussion, it is of significantly lower amplitude and shorter duration (60-90 ms), with greater F2 variability conditioned by the flanking consonants, as the speaker has low rank for this vowel.

NigE realisations, in contrast, show a major divergence. In the NURSE set, many speakers produce a fronter, lower quality vowel, whose F1 rises to 650-750 Hz, and which either rises (towards [ɛ]) or falls (towards [ɔ] or [a]) in F2, depending on the orthography; bird and early are more likely to approach [ɛ] or [a], whereas journal more often yields a backer [ɔ]-like quality. The NigE token's durations are systematically shorter and the amplitude envelope less steady, indicating incomplete length contrast. The tokens of schwa in brother, butter and discussion rarely exhibit the anticipated reduction, but rather occur as full vowels, whose formant values are similar to the orthographic vowel (commonly [ɔ] or [a] in brother and butter and [ɪ] or [ɛ] in discussion). The mean amplitude is higher and the duration longer than in RP, eroding the stress-timed rhythm of these tokens of schwa.

Statistical comparison confirms significant group differences on all measured parameters ($p < .01$ for F1 and duration of both vowels and $p < .05$ for F2 of NURSE). The NigE vowel space is compressed in its central region, overlapping the peripheral qualities /ɛ/, /a/ and /ɔ/. These patterns fit with the predictions of SLM of category assimilation and with the formant plots found earlier (Jamakovic & Fuchs, 2019; Bello et al., 2020).

The quantitative results are summarised in the following tables.

Table 1. Mean acoustic values for the NURSE vowel /ɜː/ in **bird, early and journal**

Parameter	RP Mean (SD)	Nige Mean (SD)	Difference	P-Value
F1 (Hz)	548 (42)	712 (68)	+164 Hz	< .01
F2 (Hz)	1498 (61)	1425 (95)	–73 Hz	< .05
Duration (ms)	198 (24)	142 (31)	–56 ms	< .01
RMS Amplitude (dB)	–12.4 (2.1)	–15.8 (2.9)	–3.4 dB	< .01

The raised F1 values in Table 1 reflect a marked downshifting of the NURSE vowel in Educated NigE relative to the RP target. As the vowel moves inwards from the periphery of the vowel space, it approaches those corresponding to open or open-mid vowels that dominate in the majority of the Nigerian Languages. The simultaneous decrease in duration by 56 ms reveals only a partial neutralisation of the distinctive length contrast between /e/ and its short equivalent in RP, which again matches with the general lack of phonemic vowel contrast in Southern Nigerian English as previously noted. The observed drop in RMS amplitude may also suggest that the NigE speakers do not have the ability to maintain the vowel in its intended shape as long as they desire, thus resulting in the less consistent spectral content. Together they seem to confirm that the central value of /e/ is neither targeted independently nor retained through time, and that their realisation is governed by orthographic cues and the existence of similar categories in the speakers' L1, and that is the reason why their substitutes detected from auditory and broader formant studies are what they are.

Table 2. Mean acoustic values for schwa /ə/ in **brother, butter, and discussion**

Parameter	RP Mean (SD)	Nige Mean (SD)	Difference	P-Value

F1 (Hz)	512 (55)	648 (79)	+136 Hz	< .01
F2 (Hz)	1560 (110)	1485 (125)	–75 Hz	< .05
Duration (ms)	74 (18)	118 (27)	+44 ms	< .01
RMS Amplitude (dB)	–18.6 (2.8)	–14.2 (3.1)	+4.4 dB	< .01

Table 2 shows that schwa undergoes a complementary set of changes. The rise in F1 of 136 Hz again signals lowering and decentralisation, while the increase in duration of 44 ms and the rise in RMS amplitude of 4.4 dB demonstrate that the vowel is realised as a full, relatively intense nucleus rather than as a reduced, low-energy segment. In RP, schwa's short duration and low amplitude are primary cues to unstressed status and contribute to the stress-timed rhythm of the variety; their attenuation in NigE therefore erodes that rhythmic contrast. The slight drop in F2 indicates vowel retraction. This reflects the replacement of schwa with [ɔ] and [a] in words containing or as can be seen. These acoustic factors indicate that vowel reduction does not occur as it does in British English. This has previously been noted by subjective listening and acoustic results in Nigerian English.

Higher F1 values. The shorter vowel durations in Nigerian English indicate that there is a clear lowering and shortening of the central vowel targets. The differences in loudness also indicate that emphasis is placed on the reduced, weak schwa sounds. The NURSE vowel is not sustaining long constant energy at that point in the word as we would expect with long vowels in Received Pronunciation. These acoustic findings indicate that there is some restructuring taking place in the central region of the vowel system, depending on the speaker's language and clarity of spelling.

The diagrams of the six words also indicate a structured change in vowel production. The changes in F1 values (roughfully 1.5 To 2 Bark) indicate that the vowels in Nigerian English are well outside the typical central region of Received Pronunciation. This supports the idea that vowel sounds are changing quite dramatically and are being placed into new distinct groups. The schwa and NURSE vowel are both undergoing a change whereby they are becoming similar to other vowels within the system.

5.1 Conclusion

The acoustic substantiation shows that Educated Nigerian English makes a systematic change to the two key vowels of English. Both /ə/ and /ɜ:/ differ considerably from RP: the vowels have become unstable and have higher and/or more variable F1 values. They also demonstrate reduced vowel duration and different amplitude patterns. This was seen across all diagnostic words (brother, butter, discussion, bird, early and journal). This can be explained due to interactions between the L1 phonology and the impact of orthography.

This study reaffirms the autonomy of Nigerian English through the findings of a stable central vowel region. This study also demonstrates the importance of the central vowel region when considering teaching pronunciation, adapting speech technologies and researching intelligibility. The quantification of the difference in the F1 values, duration and amplitudes of these vowels can guide future vowel training tools using formants, adapting automatic speech recognition software which may be trained predominantly on RP or General American and further intelligibility experiments. In the future, spontaneous speech should be included along with more ethnolinguistic participants and tracking younger speakers over time to understand how and why these differences occur. Monitoring New English Native Speakers could provide insight into whether decentralisation remains or endonormative pressures cause speakers who use English as a primary language to become more centralised.

5.2 Recommendations

1. Pronunciation teaching materials for Nigerian learners should prioritise explicit formant-based training on /ɜː/ and schwa reduction, and spectrographic visualisation should be incorporated into curricula so that learners can perceive the target vowel quality.

2. Speech-recognition programmes based on RP should have adaptive modules addressing NigE vowel substitutions, and teacher-training materials should provide a rudimentary competence in acoustic-phonetic interpretation, including F1/F2 analysis.

3. Additional large-scale corpora studies should extend the current design to spontaneous speech and other ethnolinguistics, Also, Nigerian English lexicographical resources should be enriched with information on dominant acoustic realisations of /ə/ and /ɜː/

4. Orthography-sensitive interventions may help to eliminate spelling-motivated replacements of NURSE. Likewise, Intelligibility work should address the role of central vowel interference on comprehension breakdown

5. Comparative sociolinguistic studies are required of NigE and other West African varieties to establish regional trends in vowel quality; hence, funders should support longitudinal acoustic monitoring of younger “New English Native Speakers” in order to detect endonormative trends

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