

Acoustic Evidence for Partial Temporal Restoration in Syllable and Segmental Deletion in Igbo

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Abstract

Compensatory lengthening is commonly described as a process in which the deletion of a segment or syllable is accompanied by the lengthening of an adjacent segment. This study examines the acoustic evidence for partial temporal restoration following syllable and segment deletion in Igbo. Speech data were obtained from six adult native speakers of Igbo, comprising three males and three females. The speakers produced selected words and utterances representing different phonological environments in which segmental or syllabic deletion occurs. The recordings were analysed acoustically using Praat, with particular attention to the duration of the segments and syllables involved before and after deletion. The analysis shows that deletion is frequently accompanied by an increase in the duration of an adjacent vowel. However, the measured duration of the lengthened vowel does not consistently equal the combined duration of the deleted sequence and the vowel that remains. The acoustic evidence therefore points to partial rather than complete temporal restoration. The findings suggest that, although vowel lengthening contributes to the recovery of temporal material following deletion, it does not necessarily reproduce the full duration of the original sequence. The study provides acoustic evidence that explains the occurrence of compensatory lengthening and the degree of temporal restoration achieved through the process.

Keywords: *compensatory lengthening, temporal restoration, segment deletion, syllable deletion, acoustic phonetics, Igbo.*

1. Introduction

The relationship between segmental deletion and the temporal organisation of speech has long attracted attention in phonological and phonetic research. In many languages, the loss of a segment or syllable may be accompanied by an increase in the duration of a neighbouring segment, most often a vowel. This phenomenon is generally referred to as compensatory lengthening. While the occurrence of lengthening following deletion is relatively well established, it remains uncertain whether the additional duration of the surviving segment fully or partially replace the temporal material lost through deletion. This can be examined through acoustic measurements rather than solely through phonological description.

Earlier phonological accounts have often interpreted the process of compensatory lengthening as a means of maintaining prosodic structure following the loss of phonological material (Hayes, 1989; Kavitskaya, 2002). From this perspective, the lengthening of an adjacent segment is not simply an incidental increase in duration but forms part of a broader response to segmental loss. However, the phonetic realisation of such processes may not always correspond directly to the structural relationships proposed in phonological accounts. Acoustic evidence has shown that the duration of a lengthened segment may fall short of the combined duration of the deleted material and the segment that remains (Kavitskaya, 2002). This raises an important distinction between the occurrence of compensatory lengthening and the extent of temporal restoration achieved.

Although previous descriptions of Igbo phonology have provided important accounts of the language's syllable structure, vowel system, tone, and morphophonological processes, these descriptions have generally concentrated on the structural outcomes of deletion and related phonological alternations (Emenanjo, 1978; Green and Igwe, 1963; Mbah and Mbah, 2010). Comparatively less attention has been given to the acoustic consequences of such deletion, particularly the extent to which an adjacent vowel increases in duration and whether the increase is sufficient to restore the temporal material lost through deletion.

This gap is what the study intends to fill by investigating the acoustic consequences of syllable and segment deletion in Igbo, with particular attention to the duration of segments before and after deletion. Through instrumental acoustic analysis, the study examines a number of phonological environments in which deletion is accompanied by the lengthening of an adjacent vowel so as to determine whether the increase in vowel duration is sufficient to restore the temporal duration of the original sequence or whether the process results in only partial restoration.

2. Literature Review

Acoustic phonetics is concerned with the physical properties of speech sounds and the measurable characteristics of the sound signal produced during speech. These properties include frequency, intensity, and duration, which provide different forms of information about speech production and perception (Crystal, 2007; Reetz and Jongman, 2009; Kent and Read, 2015; Ladefoged and Johnson, 2015). Acoustic analysis makes it possible to examine speech phenomena through instrumental measurements rather than relying exclusively on auditory impressions or phonological descriptions.

Of the major acoustic parameters, duration is particularly relevant to the present study. Duration refers to the amount of time occupied by a speech segment or larger prosodic unit. It can be measured from acoustic recordings using tools such as waveforms and spectrograms, allowing researchers to compare the temporal properties of speech sounds across different contexts (Kent and Read, 2002; Reetz and Jongman, 2009). In studies of deletion and compensatory lengthening, duration is especially important because the central issue is whether the temporal loss associated with deletion is followed by a measurable increase in the duration of a surviving segment.

Compensatory lengthening has traditionally been described as a phonological process in which the deletion of one segment is accompanied by the lengthening of another, usually an adjacent vowel. Crystal (2007) describes it as an effect in which the deletion of one segment is accompanied by an increase in the length of another segment, thereby maintaining aspects of syllable weight. Similar descriptions are found in broader phonological accounts, which associate the process with the preservation of prosodic structure following segmental loss (McCarthy and Prince, 1986; Hayes, 1989; Kavitskaya, 2002; Gouskova and Stanton, 2020; Côté, 2022)). However, descriptions of compensatory lengthening have often focused on the structural relationship between deletion and lengthening without sufficiently addressing the extent to which the lost temporal material is actually recovered.

Previous studies have shown that compensatory lengthening occurs across languages, but its phonological conditioning and phonetic realisation are not uniform (Hayes, 1989; Kavitskaya, 2002). The evidence suggests that temporal compensation may vary according to the type of segment deleted, the segment that undergoes lengthening, and the phonological environment in which the process occurs. Similarly, in Bantu languages, such as Chichewa, Downing (2005) demonstrates that tone stability is prioritized during compensatory processes, raising questions about whether similar behaviour occurs in Igbo, a language with equally intricate tonal patterns.

Igbo, a major Benue-Congo language spoken predominantly in southeastern Nigeria, provides an interesting context for investigating compensatory lengthening because of its relatively simple syllable structure; with vowel-only (V), syllabic nasal (N), and consonant-vowel (CV) syllables, while consonant clusters are generally restricted. Processes such as vowel deletion, consonant deletion, assimilation, and other morphophonological alternations occur in different phonological and grammatical environments (Emenanjo, 1978; Green and Igwe, 1963; Mbah and Mbah, 2010). Such processes create opportunities for examining what happens to the temporal

organisation of speech when a segment or syllable is removed. Although these studies provided an understanding of the structural conditions under which deletion takes place, their primary concern is phonological and grammatical description rather than the acoustic measurement of the temporal consequences of deletion which is addressed in the present study.

The limitation is therefore not that deletion and related alternations have been ignored in the description of Igbo. Rather, what remains insufficiently examined is what happens to speech duration when such deletion occurs. do not adequately answer the temporal question addressed in the present study. The study therefore tries to determine the extent to which this increase in duration restores the temporal material lost through deletion. Addressing a specific gap in the literature by providing acoustic evidence for partial temporal restoration in Igbo.

3. Methodology

The study adopted a descriptive research design supported by instrumental acoustic analysis. Data were obtained from six adult native speakers of Igbo, comprising three males and three females, between the ages of 25 and 45 years randomly selected based on their native-speaker competence in Igbo. The participants produced selected lexical items and carefully constructed utterances representing different phonological environments in which segmental or syllabic deletion occurs. These environments were selected to allow comparison of the temporal effects of deletion across different phonological contexts.

The speech samples were recorded in a quiet environment using Zoom H1n digital recorder which is suitable for acoustic analysis. The recordings were subsequently analysed using Praat (Boersma & Weenink, 2025). The analysis focused primarily on segmental and syllabic duration, with measurements taken from the words before deletion and from the corresponding forms following deletion and vowel lengthening. The differences were calculated using inferential statistics. This enables comparison between the duration of the original sequence with the duration of the corresponding sequence after deletion. The tone-marking convention used in the study follows Green and Igwe (1963), in which high tone is left unmarked, low tone is marked with a grave accent (`), and downstep is represented by a macron (¯).

4. Data Presentation and Analysis

4.1. Presentation of different deletion environments in Igbo

This section presents instances involving the deletion of the *rV* past marker, consonant deletion, vowel deletion in compound formation, deletion of the vowel /a/ in the auxiliary construction *na*, and deletion of linking consonants. These environments demonstrate were selected to allow comparison of the temporal effects of deletion across different phonological contexts.

A. Deletion of rV past marker in Igbo

CVCV → CVV

(1) +ATR vowel constructions

a. Sirì	→	sìì	‘cooked’
b. Tèrè	→	tèè	‘rubbed’
c. Mèrè	→	mèè	‘did’
d. Jèrè	→	jèè	‘went’
e. Zòrò	→	zòò	‘rained’
f. Kwèrè	→	kwèè	‘sang’
g. Kwùrù	→	kwùù	‘said’\

(2) –ATR vowel constructions

a. Gàrà	→	gàà	‘went’
b. Dàrà	→	dàà	‘fell’
c. Rị̀rị̀	→	rị̀rị̀	‘climbed’
d. Kùrù	→	kùù	‘hit’
e. Chọ̀rọ̀	→	chọ̀ọ̀	‘wanted’
f. Zàrà	→	zàà	‘answered’
g. Mùrù	→	mùù	‘birthed’

The examples above involves the deletion of *rV* segments in that indicate past actions in Igbo language. The data show that deletion of the *-rV* past tense marker consistently triggers compensatory vowel lengthening in Igbo. As illustrated in Examples (1) and (2), the deletion of the final syllable results in the progressive lengthening of the preceding vowel in order to create a balance thereby compensating for the deleted syllable. The tone of the deleted syllables in the examples above shifted to the new lengthened vowel and is apparently preserved.

Closely examining the examples above, some scholars may argue that it is just the lateral /r/ that got deleted and not the whole syllable but the examples below made it clear that it is the syllable that is deleted not just the lateral /r/. Let us consider examples from some Igbo dialects:

(3a). Bìàlù	→	bìàà	‘came’
b. Mèlù	→	mèè	‘did’
c. Tàlù	→	tàà	‘chewed’
d. Kwèlù	→	kwèè	‘agreed’
e. Kèlù	→	kèè	‘shared’
f. Sònyèlù	→	sònyèè	‘joined’
g. Gbàlù	→	gbàà	‘ran’

The acoustic evidence provided below demonstrated that the vowel sound clearly undergoes temporal expansion after deletion, but the resulting duration remains shorter than the duration of the original sequence. This finding provides empirical support for Kavitskaya's (2002) argument that compensatory lengthening frequently results in partial, rather than complete, temporal compensation.

B. Deletion of consonants within segments

(4) +ATR vowel constructions

a. Osi	→	ooisi	‘stick’
b. Ùzuzù	→	ùuuzù	‘dust’
c. Òkwùkwe	→	òùùkwe	‘faith’
d. Òfùfè	→	òòùfè	‘worship’
e. Òtìto	→	òòìto	‘praise’

(5) –ATR vowel constructions

a. Àzìzà	→	ààìzà	‘broom’
b. Arurù	→	aaurù	‘ants’
c. ọkụkọ	→	òòùkọ	‘chicken’
d. ahụhụ	→	aauhu	‘suffering’
e. Akụkọ	→	aaụkọ	‘story’

The examples above illustrate a consistent phonological pattern in which the deletion of an intervocalic consonant is accompanied by the temporal expansion of an adjacent vowel. The lengthened vowel compensates for the structural disruption created by consonant deletion, thereby preserving the rhythmic organization of the word.

C. Deletion of vowel segment in compound words

(6a). aka ‘hand’	+	osè ‘pepper’	=	akoosè ‘peppery hand’
b. Ùde ‘cream’	+	isi ‘head’	=	ùdiisī ‘hair cream’
c. ijè ‘walk’	+	oma ‘good’	=	ijòoma ‘good journey’
d. ụlò ‘house’	+	akwụkwọ ‘book’	=	ulàakwụkwọ ‘school’
e. nwa ‘child’	+	oma ‘good’	=	nwọoma ‘good child’
f. ụlò ‘house’	+	ụkà ‘church’	=	ulụuka ‘church building’
g. itè ‘pot’	+	òbàrà ‘blood’	=	itòbàrà ‘pot of blood’

These examples demonstrate that when two lexical items are combined, the vowel at the boundary of the first word is frequently deleted, while the initial vowel of the second word undergoes compensatory lengthening. The process eliminates vowel hiatus without disrupting the rhythmic organisation of the resulting compound. The direction of compensation is predominantly regressive, since the vowel belonging to the second constituent lengthens to compensate for the deleted vowel of the first constituent.

This pattern is consistent with previous descriptions of Igbo morphophonology, which identify vowel deletion as a common strategy for resolving hiatus in connected speech and word formation, although some scholars explain the process as complete assimilation (Green & Igwe, 1963; Emenanjo, 1978; Mbah & Mbah, 2010). However, for a vowel to assimilate a neighboring sound completely, the neighboring sound loses its distinct features, so there is loss of a segment which requires restoration through lengthening.

D. Deletion of the /a/ vowel in the auxiliary verb ‘na’

(7a). nà-èkwu	→	nè-èkwu	‘is saying’
b. nà-èsi	→	nè-èsi	‘is cooking’
c. nà-ème	→	nè-ème	‘is doing’
d. nà-èbe	→	nè-èbe	‘is crying’
e. nà-ese	→	nè-ese	‘is drawing’
f. nà-efè	→	nè-efè	‘is worshipping’

The examples reveal a regular morphophonological process in which the low vowel /a/ of the progressive auxiliary is deleted when followed by the infinitival prefix /e-/. This is only realizable when the first syllable of the main verb is of the advanced tongue root /e/, the retracted tongue root /a/ does not show the deletion and lengthening because it

is identical with the vowel segment of the auxiliary verb. That is, this instance of deletion and compensatory lengthening is observed when the auxiliary verb co-occurs with the +ATR infinitive /e/. Rather than producing a hiatus between adjacent vowels, the language resolves the sequence through deletion accompanied by temporal expansion of the surviving vowel. The resulting lengthened vowel maintains the prosodic continuity of the construction while preserving the phonological integrity of the utterance.

Unlike the previous environments discussed in this study, compensatory lengthening here is conditioned primarily by grammatical structure rather than lexical phonology. The process operates across word boundaries within the verb phrase, demonstrating that compensatory lengthening in Igbo extends beyond lexical representations to include morphosyntactic constructions. This finding suggests that phonological repair mechanisms are sensitive not only to segmental configuration but also to grammatical relationships between adjacent morphemes.

E. Deletion of symmetry consonants

(8a). èmèrème	→	èmèèème	‘caused/inflenced’
b. àkpùrùàkpù	→	àkpùùùàkpù	‘moulded image’
c. ohoroho	→	ohoooho	‘wide’
d. èkèrèke	→	èkeèèke	‘strongly tied’
e. àrùrùàrù	→	àrùùùàrù	‘handmade’

The data further reveal that compensatory lengthening occurs following the deletion of the symmetry (linking) consonant /r/ in selected Igbo lexical items. This deletion is systematically accompanied by the lengthening of V2, this lengthening results to a pause/break for example, ekee.eke, aruu. Aru. The examples presented above demonstrate that the deletion of the linking consonant creates a structural gap within the word, which is immediately compensated for through the temporal expansion of the neighbouring vowel. Unlike the previous environments discussed in this study, the deleted consonants do not occur at morpheme boundaries but within the internal phonological structure of lexical items, indicating that compensatory lengthening in Igbo operates across different levels of phonological organisation.

4.2. Interpretations to the Acoustic Evidence of Partial Temporal, Restoration

The acoustic analysis examined the duration of the selected words before and after deletion. Six observations were obtained for each word. To determine the extent of temporal change associated with deletion, the mean duration and standard deviation

(SD) were calculated for the pre-deletion and post-deletion forms. The results are presented in Table 1 below:

Table 1: Descriptive Statistics of Pre-Deletion and Post-Deletion Duration

Words	N	Pre-deletion Mean (ms)	Pre-deletion SD (ms)	Post-deletion Mean (ms)	Post-deletion SD (ms)
Gàrà 'went'	6	425.33	47.05	304.83	49.79
Mèrè 'did'	6	489.83	56.35	350.17	41.69
Osisì 'tree'	6	555.67	51.86	375.67	62.59
Àzìzà 'broom'	6	510.67	20.93	482.83	11.36
ùdeisī 'hair cream'	6	455.83	46.55	412.33	46.44
Ulòukà 'church'	6	455.83	46.85	407.50	49.91

Note: N = number of observations; SD = standard deviation; ms = milliseconds.

As shown in Table 1, the mean duration decreased following deletion across all six words. The largest reduction was observed in *Osisì*, where the mean duration decreased from 555.67ms (SD = 51.86) before deletion to 375.67ms (SD = 62.59) after deletion, representing a mean reduction of 180.00ms. This is followed by *Mèrè*, with a reduction of 139.67ms, and *Gàrà*, with a reduction of 120.50ms. These three forms retain approximately 67.61%, 71.49%, and 71.67%, respectively, of their original mean duration after deletion. The results suggest that, although temporal expansion occurs in the post-deletion words, it does not fully recover the duration associated with the original sequences.

In contrast, *Àzìzà* recorded the smallest reduction, from a pre-deletion mean of 510.67ms (SD = 20.93) to a post-deletion mean of 482.83ms (SD = 11.36), retaining approximately 94.55% of the original duration. *ùdeisī* retains 90.46%, while *Ulòukà* retains 89.40%. The relatively small differences in these words suggest a greater degree of temporal restoration than in *Gàrà*, *Mèrè*, and *Osisì*. However, because the post-deletion means remain lower than the pre-deletion means, the data still indicate that the restoration is not consistently complete.

The differences between the pre-deletion and post-deletion mean durations are further illustrated in Figure 1.

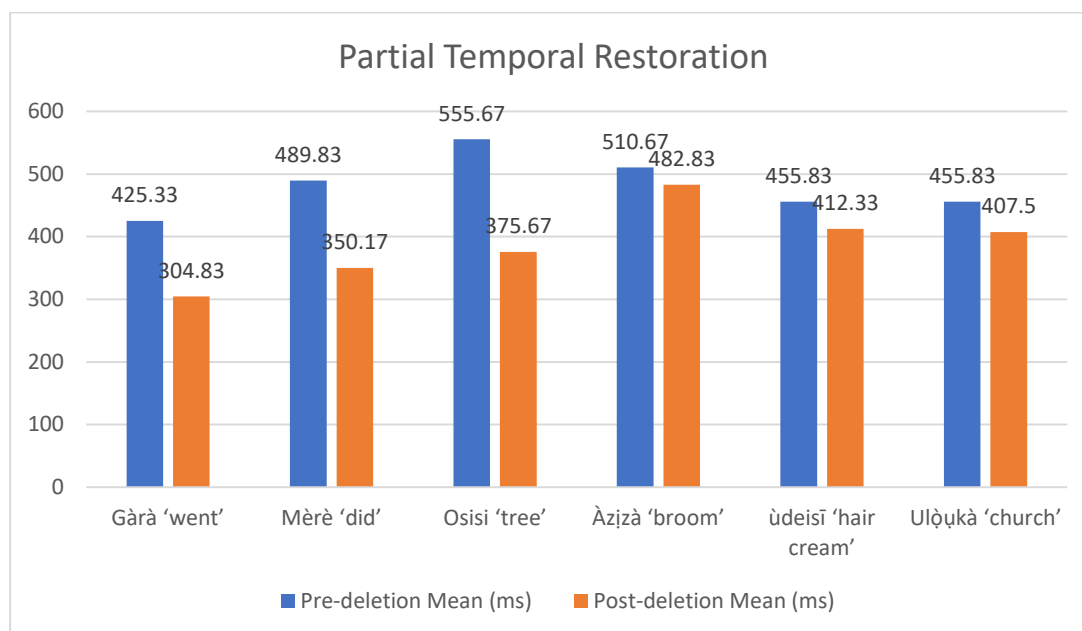


Figure 1: Mean Duration Before and After Deletion

As illustrated in Figure 1, the reduction in mean duration is more pronounced in *Gàrà*, *Mèrè*, and *Osisi* than in *Àzịzà*, *ùdeisī*, and *Ulòyukà*. This suggests that the temporal effect of deletion varies across words, with some environments exhibiting a greater degree of restoration than others. However, none of the words show complete restoration based on the mean durations.

The results demonstrate that deletion is associated with a reduction in overall duration, but the magnitude of this reduction varies across phonological environments. The variation in the proportion of duration retained suggests that temporal restoration is not uniform. While the post-deletion forms show evidence of temporal expansion of the surviving material, the mean durations remain below the corresponding pre-deletion values. The findings therefore provide acoustic evidence for partial rather than complete temporal restoration.

5. Conclusion

This study examined acoustic evidence for partial temporal restoration in syllable and segment deletion in Igbo. It analysed five phonological environments in which segmental or syllabic deletion is accompanied by the lengthening of an adjacent vowel. These include the deletion of the *-rV* past tense marker, consonant deletion within lexical items, vowel deletion in compound formation, deletion of the vowel /a/ in the

progressive auxiliary *na*, and deletion of linking consonants. The results show a recurring relationship between deletion and vowel lengthening.

However, the data demonstrate that compensatory lengthening in the words examined is better understood as a process of partial temporal restoration rather than complete temporal replacement. The acoustic measurements also reveal that the increase in vowel duration does not consistently reproduce the full temporal duration of the original sequence. The degree of temporal recovery also varies across the phonological environments examined. Thus, the findings suggest that vowel lengthening following deletion results in partial rather than consistently complete temporal restoration.

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