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An Acoustic Evaluation Of Syllabic Consonants Validating The Consonantalized Nasal Vowel Schwa.

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Abstract
This study examines the final syllable in English words like "written " (/ˈritən) and "Sudden" (/ˈsʌndən/) (p. 1). Standard grammar and phonological frameworks often claim that the weak vowel Schwa \(([ə])\) is completely elided in these phonological contexts, creating only a "syllabic consonant" \([n̩]\) (p. 1).
First, the study proves that this dominant theory is incorrect (p. 1). By applying the sound analysis software Praat across an expanded sample of 60 subjects, it was revealed that the vowel is not missed (pp. 1, 3). The digital data reflects that this syllable has a long duration and maintains a consistent energy level driven by continuous glottal pulses (pp. 1, 5). A consonant alone cannot sustain this realization without airflow coming from an underlying vowel (p. 1).
Second, the study shows the real physical process behind this sound transition (p. 1). The vowel is not elided; it simply modifies its airflow trajectory (p. 1). Because the speech organs optimize muscle effort in unstressed positions, the soft palate (velum) opens early (p. 1). This behavior passes the air passage of the vowel into the nasal cavity instead of the oral one (p. 1). Simultaneously, the compression from the previous sound pressures the vowel space (p. 1). This concept has been coined as the Consonantalized Nasal Vowel Schwa (CNVS) (p. 1). The vowel remains inside the sound as a hidden motor that keeps the syllable structurally stable (p. 1).

Keywords: *Acoustic Phonetics, Schwa Deletion, Syllabic Nasal, CNVS, Praat Analysis, Airflow.*

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I. Introduction And Theoretical Framework

In Received Pronunciation (RP) and Standard British English dictionaries, the final syllable of words like "Cotton" (/ˈkɒt.ən/) or "London" (/ˈlʌndən/) is drawn with a small vertical line under the "n" like this: \([n̩]\) (p. 1). This symbol expresses a syllabic nasal (p. 1). This traditional method of writing claims a process called Material Elision, which simply means that the weak vowel Schwa \(([ə])\) is completely elided during real-time speech production (p. 1).

This study validates that this old claim is just a shortcut notation and does not accurately indicate the acoustic signal of human speech (p. 1). By using digital speech analysis via Praat, the study demonstrates that the vowel never disappears (p. 1). Instead, because the sounds are uttered very close to each other, the schwa vowel undergoes nasalization (air passes through the nose) and structural compression at the same time (p. 1). The study proposes this model as the Consonantalized Nasal Vowel Schwa (CNVS) (p. 1). The vowel is still there, working as a hidden syllable core (a hidden power center) inside the nasal flow (p. 2).

Statement of the Problem

"The study problem is addressing phonological phenomena studies by Alwasila (2022) to criticize the classical modeling Syllabic Consonant Theory which has been widely accepted among the linguistic communities and English dictionaries designers. Syllabic Consonant Theory established conceptual " material Elision" which claimed that the sound schwa in the final syllable of a word /cvəc/ which is exposes to a fatal deletion. The centralized Schwa Model established a theoretical evidence that schwa in the final syllable of a word is not elided, but this study is not scientifically equate, instead it is lack of a pronounced anatomical-acoustic to state the hidden structural engine of the syllable gap.

"The importance of this study is to address and a criticize a gap in both theoretical phonology and computational speech analytics. Theoretically, this research the foundational consonantalized framework established by Alwasila (2022) by furnishing the first large-scale empirical and quantitative validation of the Consonantalized Nasal Vowel Schwa (CNVS) using a comprehensive 60-subject cohort. By deconstructing the long-standing 'Material Elision' fallacy, this study constrains a necessary update to syllabic consonant model.in the term of dictionaries, modern speech recognition engines, and synthetic voice development.

II. A Formal Criticism Of The Syllabic Consonant Paradigm

The major defect of the traditional syllabic consonant theory \([n̩]\) is concluding that speech operates like a digital switch (either the vowel is present, or it is absent) (p. 2). However, real physics and Acoustic Phonetics verify that speech is a continuous, analog wave of air (p. 2).

From a factual acoustic view, an ideal consonant phoneme cannot constitute a syllable nucleus by itself, double its steady-state duration to 120–180 ms, and maintain a strong 50 dB energy level without a continuous flow of air from the vocal cords (p. 2).

Therefore, the phonetic transcription of words like "Cotton" with a pure \([n̩]\) is just an option for lexicographers (p. 2). It tricks the human ear because the loudness of the nasal sound "n" captures the weak vowel (p. 2). This phenomenon is Auditory Cognitive Masking (McClelland & Elman, 1986) (p. 2). The classical theory obscures a mixed sound with the complete deletion of a sound (p. 2). Only the CNVS model can solve this anomaly using raw acoustic data (p. 2).

III. Aerodynamic Mechanism And Articulatory Kinematics

When uttering the end of the word "Cotton" \([-tən]\), the tongue and air do not move instantly from \([t]\) to \([n]\) (p. 2). The air pressure changes smoothly across four clear physical steps (p. 2):

- **Phase 1: The Plosive Release Burst:** First, the air is completely blocked behind closure that is made by tip of the tongue and the alveolar ridge to make the \([t]\) sound (p. 2). When the tongue moves slightly, the blocked air explodes out quickly, producing a sharp noise that lasts 10 to 30 ms (p. 2).
- **Phase 2: The Implosive Transition Gap \((\Delta t)\):** Subsequently, after the explosion, there is a very short Voice Onset Time (VOT) Gap lasting 5 to 15 milliseconds (p. 2). In this micro-gap, the air pressure pushes backward (p. 2). The oral cavity stays narrowed because the tongue is active to utter the next sound \([n]\) (p. 2).
- **Phase 3: The Nasal Plosion Trigger:** Because this syllable is unstressed, the brain sends a signal to optimize muscular effort (Norris, 1994) (p. 2). Thus, the oral cavity is closed early (p. 2). Instead of velopharyngeal closure, it opens the nasal cavity while the tongue is still blocking the oral cavity (p. 2). This forces the compressed air to explode through the nose, creating a "nasa explosion" (p. 2).
- **Phase 4: Spectral Absorption and Consonantalization:** The schwa vowel is caught between the back-pressure of the [t] and the strong pull of the nose (p. 2). It loses its oral distinctive features (p. 3). The airflow escapes completely through the nasal cavity, which reduces its clear vowel quality (p. 3). This process changes the vowel into a consonant-like sound (consonantalization) (p. 3). It is absorbed by /n/, but its energy stays alive inside the syllable (p. 3).

IV. Methodology And Experimental Calibration

Subject Cohort and Sampling Design

To validate the aerodynamic and acoustic properties of the Consonantalized Nasal Vowel Schwa (CNVS) (p. 3), this empirical study Deploys data panel of 60 native English-speaking participants (p. 3). To ensure absolute acoustic homogeneity and eliminate macro-phonetic variance, all 60 participants were strictly filtered down to be mono-dialectal native speakers of Brith English RP, demonstrating zero phonetic indicators of regional convergent accents: The participants were divided equally into two distinct experimental groups (p. 3):

- **Target Group (N = 30):** Native SBE speakers, balanced strictly for biological sex (15 female students and15 male students), designated to utter the phonological target words (p. 3).
- **Control Group (N = 30):** Native Speakers of British English speakers, balanced equally (15 male students and 15 female students), tasked with uttering non-syllabic standard control contexts to compute immediate spectral decoupling and absolute vowel deletion boundaries (p. 3).

Target Token Lexicon Expansion

The phonetic sample corpus lists of **10 disyllabic words** (/ˈC_1 V C_2.ən/) have explicitly selected where the final unstressed syllable core constitutes s as the nucleus whose underlying the dominant neutral Schwa vowel (/ə/), closed by a terminal alveolar nasal stop (/n/) (p. 3):

Fuger 4.2.

#	Target Disyllabic Token	Phonetic Environment	Underlying Nucleus	Terminal C
1	Cotton	/ˈkɒt.ən/	Schwa /ə/	/n/
2	London	/ˈlʌndən/	Schwa /ə/	/n/
3	Button	/ˈbʌt.ən/	Schwa /ə/	/n/

4	Sudden	/ˈsʌd.ən/	Schwa /ə/	/n/
5	Hidden	/ˈhɪd.ən/	Schwa /ə/	/n/
6	Kitten	/ˈkɪt.ən/	Schwa /ə/	/n/
7	Burden	/ˈbɜːd.ən/	Schwa /ə/	/n/
8	Ritten	/ˈrɪt.ən/	Schwa /ə/	/n/
9	Pardon	/ˈpɑːd.ən/	Schwa /ə/	/n/
10	Glottan	/ˈglɒt.ən/	Schwa /ə/	/n/

Data Ingestion and Laboratory Protocol

All 60 subjects recorded these 10 target utterances inside an acoustic isolation booth using an omnidirectional condenser microphone calibrated via the Praat laboratory workspace (p. 3). The obtained data workflow derived a comprehensive acoustic matrix verfying that a consonant alone cannot maintains this pronunciation without latent airflow (pp. 3-4).

V. Acoustic Metrics And Baseline Controls

Target Token Analysis: The Three Acoustic Metrics

- **Metric 1: The Principle of Nucleus Duration Extension:** In rapid speech, a regular, short "n" sound contuse for only 60 to 80 milliseconds (p. 4). However, Praat proves that the target closed rhyme continues primarily longer (p. 4). Phonetically, a consonant cannot lengthen double length unless there is a vowel inside making it with extra air and time (p. 4).
- **Metric 2: The Energy Cushion Phenomenon:** The target schwa sound shows that the energy is degreased slightly during the acoustic void, but then stays flat and steady like a cushion (p. 4). This constant energy plateau shows that the vocal cords are vibrating continuously, which is a distinctive feature of vowels, not consonants (p. 4).
- **Metric 3: Low-Frequency Formant Trajectory Tracking:** If the schwa vowel was elided, the sound bands (formants) would break and scatter (p. 4). However, a Wideband Spectrogram in Praat shows that the main spectral band (F_1 and F_2) are not deleted (p. 4). They flatten out and form a steady low band at 250 Hz (p. 4). This shows that the pharynx maintains a vowel shape even while air escapes through the nasal cavity (p. 4).

Control Sample Analysis: The Behavior of Non-Syllabic Nasals

To verify that the study findings are valid, the target schwa and /n/ sounds were analyzed in a different word, "strongly", to use as a baseline for comparison (p. 4). In the word "strongly", there is a direct movement from the vowel [\ɒ] to the nasal sound \([\eta]\) and then to the liquid sound \([l]\) (p. 4). Praat proves that the energy is reduced immediately and sharply (p. 4). There is no silence gap \((\Delta t)\) and no stable energy baseline (p. 4). The nasal sound is not long , showing empirical evidence: when a vowel truly dissipates, the sound wave drops instantly without saving any hidden space (p. 4)

VI. Empirical Results And Discussion

Comprehensive Parametric Matrix

The following multi-subject dataset captures the c**alibr**ated acoustic parameters delived via the Praat laboratory workspace across all 60 subjects (p. 5). To avert artificial skewness presentation and safeguard rigorous statistical integrity, data are presented as Mean ± Standard Deviation (M ± SD) (p. 5):

Table 6.1: Calibrated Acoustic Metric Output across Experimental Cohorts (N=60)

Acoustic Feature	**Target Males (n=15)**	**Target Females (n=15)**	**Control Group (n=30)**	**Canonical Claims**	**Statistical Significance (p-value)**
Syllable Nucleus Duration	138.5 ± 8.2 ms	158.2 ± 9.4 ms	64.1 ± 4.3 ms	60 – 80 ms	$p < .001$
Energy Cushion Plateau	47.3 ± 1.4 dB	51.6 ± 1.8 dB	0.0 ± 0.0 dB	0 dB	$p < .001$
Silence Transition Window (Δ t)	8.2 ± 1.1 ms	11.4 ± 1.6 ms	0.0 ± 0.0 ms	0 ms	$p < .005$
First Nasal Murmur Formant (F_1)	241.0 ± 6.5 Hz	264.8 ± 7.1 Hz	Spectral Zero	Total Absence	$p < .001$

Contextual Environment and Aerodynamic Variations

A two-way ANOVA show a primary impact of the preceding stop voicing status on the underlying Schwa articulation (p. 5):

- **Voiceless Plosive Onsets /t/** (*Cotton, Button, Kitten, Ritten, Glottan*): These environments bring a explosion phase (p. 5). The subsequent silent gap (Δ t) is highly uttered, reaching its highest duration of 11.4 ± 1.6 ms in female tracks (p. 5). This shows a more intense aerodynamic backpressure before the occurrence of nasal release (p. 5).
- **Voiced Stop Onsets /d/** (*London, Sudden, Hidden, Burden, Pardon*): All Because voicing is already active during the preceding consonant, the acoustic energy shuts during transitions cohesively into the latent schwa space (p. 5). This exists a continuant energy plateau that permanently pluteuses at a high ceiling (M = 52.4 dB, SD = 1.1), maintaining a much thicker acoustic signature (p. 5).

VII. Acoustic Rejection Of Standard Counterpart

- **Counter-Argument 1: Ear illusion and the traditional theory:** Classical theory has concluded speakers that pronounce the consonant \([n̩]\) because the human ear hears a direct jump to the nasal sound (p. 6). This thesis confuses auditory perception with physical fact (p. 6). Acoustic occlusion is highly pervasive in human hearing (p. 6). Because the nasal sound is very sonorant and low, it completely camouflages' the weak Schwa /ə/ in our auditory verbal memory , creating the illusion that the vowel is elided (p. 6) Warren (1970). Human auditory system is not a Praat; it cannot measure air pressure waves by the millisecond (p. 6).
- **Counter-Argument 2: The explanation via compensatory lengthening:** Opponents claim the long duration of the nasal part is just compensatory lengthening, meaning the consonant stretches out to fill the empty time (p. 6). If the schwa vowel was truly elided, it would look like a cold, empty nasal murmur in Praat (p. 6). It could not display any vowel track (F_1 / F_2) or a law frequency concentration (p. 6). The lon /n/ is a mixed-source sound. because the wave driven by a nasalized vowel core (p. 6).

VIII. Conclusion

, this study has concludes that the classical "Material Elision" paradigm, which has long incorrectly claimed that the unstressed neutral Schwa vowel (/ə/) experience physical deletion within closed rhymes under the ideal penological environment of (-/ə/+/n/) (p. 6). Rather than conceding this ubiquitous perceptual restoration as an absolute elision process, this study accurately exists a groundbreaking coarticulatory framework termed "Consonantalization", appears as the "Consonantalized Nasal Vowel Schwa (CNVS)" (p. 7).

Instrumental spectrographic and waveform data directly excludes the zero-realization assumption by explaining a constant syllable nucleus core duration extending up to 180 ms, which significantly exceeds the standard 60 ms acoustic signature of standalone, non-syllabic sonorant sequences (p. 7). This lengthened period is pushed by a highly intensity speech signals processing, mathematically concluding constructive resonance by vocal cords vibration and continuous glottal air passage trans the rhyme (p. 7). Acoustic modeling in the light of thses practical findings confirm that the auditory distortion of auditory masking , furnishing that the consonantalized schwa stands as syllable nucleus and it acoustically, recalculates the traditional speech models (p. 7).

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