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A reevaluation of vowel length and lengthening in modern standard Persian

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Abstract:
This study reexamines the phonetic and phonological status of vowel length in Modern Standard Persian (MSP). Persian has undergone significant changes across its development. The preceding era, Middle/Pahlavi Persian, maintained a quantity-based vowel system in which length distinctions were phonetically and phonologically active. These historical distinctions have been reanalyzed as distinctions between two sets of vowels [a, e, o] and [ɑ, i, u] in contemporary MSP (e.g., Rahbar, 2008; Windfuhr, 2009). Previous studies report conflicting results regarding durational differences between these sets in MSP (e.g., Modarresi Ghavami, 2011; 2015; Sama'i, 2019; Aronow et al., 2017). However, the phonological distinction is widely argued to be observable in the context of compensatory lengthening (CL) triggered by glottal coda deletion, which is claimed to apply only to historically short vowels [a, e, o] and not to historically long vowels [ɑ, i, u] due to their bimoraic structure (Hayes, 1989; Darzi, 1991; Kambuzia & Hadian, 2009; Azizian & Kambuzia, 2018). To address these phonetic disagreements and reassess the phonological claim, this study reports on a production experiment with three native speakers of MSP, controlling for phonological and prosodic environments and speech rate. Results show that vowel length distinctions between the two sets were statistically significant and consistent across contexts, confirming that phonetic length remains active in MSP. However, contrary to prior literature, CL was observed across all six vowels, including historically long ones, though with weaker effects for one vowel. This finding challenges the prevailing claim that CL provides direct evidence for a categorical moraic asymmetry between historically short and long vowels. These results suggest that MSP is in a state of transition from a primarily quantity-based system to a primarily quality-based one. This study refines the description of MSP's vowel system and provides new evidence against widely held assumptions in the literature regarding the phonological conditioning of CL.

Keywords. Modern Standard Persian; vowel length, compensatory lengthening

1. INTRODUCTION

Modern Standard Persian (MSP), a branch of the Indo-Iranian group within the Indo-European language family, has a six-vowel system /i, e, a, u, o, ɑ/ (e.g., Darzi, 1991; Modarresi Ghavami, 2011; Azizian & Kambuzia, 2018). In the period preceding the modern stage of Persian, i.e., in Middle/Pahlavi Persian, the language had a phonemic distinction in vowel length for high and low vowels. The inventory included five phonologically long vowels (/iː/, /eː/, /aː/, /oː/, /uː/) and three phonologically short ones (/i/, /a/, /u/).

In the transition from Middle Persian to MSP, long vowels /eː/ and /iː/ merged to form MSP /i/, and long vowels /oː/ and /uː/ merged to form MSP /u/, as illustrated in Figure 1 by green

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arrows. Meanwhile, the short high vowels of Middle Persian lowered to form MSP mid vowels, i.e., /i/ > /e/, /u/ > /o/, illustrated via red arrows. Furthermore, the phonemic length contrast in low vowels underwent a reanalysis, distinguishing these vowels by backness rather than length, such that long vowel /aː/ was reanalyzed as /ɑ/ in MSP and short vowel /a/ was reanalyzed as /a/, as illustrated by the green and red arrows, respectively (Sadeqi, 1979; Pisowicz, 1985; Rahbar, 2008; Windfuhr, 2009).

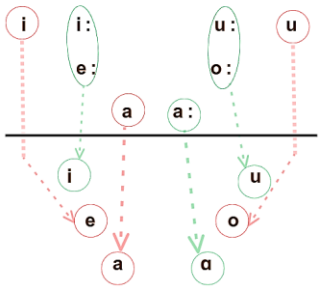

Figure 1. Diachronic development of Vowel Systems from Middle Persian to MSP
(Adapted from Pisowicz, 1985; Rahbar, 2008)

Building on this historical restructuring, contemporary MSP vowels /e, o, a/ derive from the phonologically short vowels /i, u, a/ in Middle Persian, while MSP vowels /i, u, ɑ/ descend from phonologically long vowels /iː, uː, aː/. Therefore, the vowel quantity pairs in Middle Persian (/i–iː/, /u–uː/, /a–aː/) have emerged in MSP as the vowel pairs /e–i/, /o–u/, and /a–ɑ/. This development underlies the current pairing of /e/ with /i/, /o/ with /u/, and /a/ with /ɑ/ in MSP phonetic and phonological studies, as these pairings reflect the outcomes of a shared diachronic shift in the Persian vowel system (Sadeqi, 1979; Windfuhr, 2009).

With respect to the phonetic and phonological status of vowel length in the contemporary MSP vowel pairs /e–i/, /o–u/, and /a–ɑ/, the literature presents conflicting results, both empirically and theoretically.

On the phonetic side, a substantial body of work supports the existence of durational contrasts between historically "short" vowels ([a, e, o]) and "long" vowels ([ɑ, i, u]). Early and influential studies (e.g., Windfuhr, 1979; Doustdar Toosarvandani, 2004; Tabibzade, 2007) report an approximate 2:1 duration ratio, particularly in unstressed open syllables, suggesting that vowel length remains acoustically robust. More controlled acoustic studies partially support this view: Modarresi Ghavami (2011, 2015) finds that duration differences are statistically significant, but only in restricted environments (unstressed open syllables), indicating that length contrasts are not stable across contexts. Similarly, Sama'i (2019) reports significant durational differences even in unstressed closed syllables, extending the environments in which length distinctions appear to hold.

However, another group of studies challenges the robustness of these contrasts. Sheikhsangtejan (2010) finds no statistically significant durational differences in isolated vowels, directly questioning the empirical basis of the traditional long–short classification. Feshandeki & Nourbakhsh (2012) provide mixed evidence, showing significant contrasts for /ɑ–a/ and /u–o/, but not for /i–e/, thereby undermining a consistent binary distinction across the vowel system. Even more strikingly, Aronow et al. (2017), using tightly controlled colloquial data, report reversed durational patterns, in which traditionally "short" vowels are longer than "long" ones in phrase-final contexts. These contradictions strongly suggest that vowel duration in MSP is highly sensitive

to phonological environment, speech style, and methodological design, and therefore cannot be taken to reflect a stable phonetic contrast.

This lack of convergence motivates the first research question of the present study: whether absolute and proportional vowel duration differences between these vowel pairs persist under systematically controlled phonological, prosodic, and speech-rate conditions.

Building on this phonetic disagreement, the phonological status of vowel length in MSP is equally contested. One line of research argues that vowel length is phonologically redundant, with MSP vowels distinguished solely by quality (height and backness), and any durational differences treated as phonetic by-products. In contrast, a large body of phonological work maintains that vowel length remains structurally active, encoded not as a surface contrast but as a difference in moraic representation. Diachronic accounts (e.g., Samareh, 1989; Windfuhr, 2009) trace the modern system to a historical quantity distinction, while more recent analyses (Kambuzia & Hadian, 2009; Azizian & Kambuzia, 2018) argue that this distinction persists as a monomoraic vs. bimoraic asymmetry between /e, o, a/ and /i, u, ɑ/.

The strongest evidence for this claim comes from compensatory lengthening (CL) in the context of glottal coda deletion. Under moraic accounts (Hayes, 1979, 1989; Darzi, 1991), deletion of a moraic glottal stop leaves a stranded mora that is reassigned to the preceding vowel, resulting in lengthening (e.g., /baʔd/ → [baːd]). Crucially, this process is argued to apply only to monomoraic vowels /e, o, a/ and not to already bimoraic vowels /i, u, ɑ/, supporting the claim that these two vowel sets differ in underlying weight. Alternative analyses, such as Sumner (1999), reject moraic preservation and instead derive CL through coalescence, but still maintain the same asymmetry in which only historically short vowels lengthen. More recent work (Alqahtani, 2023) further reinforces the role of moraic structure within a Stratal OT framework, while typological constraints (Hayes, 1989; Darzi, 1991) impose a two-mora ceiling on vowels, preventing further lengthening of /i, u, ɑ/.

Despite broad agreement on the existence of CL, the interpretation of this asymmetry remains theoretically divided, leaving unresolved whether it reflects an active phonological distinction or a derived, context-specific pattern.

These conflicting phonological accounts motivate the second research question of the present study: whether compensatory lengthening in MSP is indeed restricted to historically short (monomoraic) vowels in glottal coda contexts, and thus whether vowel length retains an active role in the phonological system of contemporary MSP.

2. EXPERIMENTAL EVIDENCE

This study conducted a production experiment to investigate the phonetic and phonological status of vowel length in contemporary MSP, with particular attention to compensatory lengthening (CL) triggered by glottal coda deletion.

Three native speakers of MSP participated in the experiment. All were born and raised in Tehran, the capital city of Iran. While multilingual, they reported Persian as their first and dominant language. One participant was male (Speaker #1) and two were female (Speakers #2 and #3), ranging in age from 33 to 38. None reported any history of speech, hearing, or neurological disorders. At the time of recording, all three were graduate students residing in the United States and reported regular use of Persian in daily communication. All participants had received formal education in Persian and were literate in Persian orthography.

The production experiment was designed to examine two components: (i) phonetic length distinctions in historically long–short vowel pairs in contemporary MSP, and (ii) vowel lengthening in contexts of glottal coda deletion.

The experiment was conducted in a quiet room at the Phonetics Laboratory of the Department of Linguistics (Social and Behavioral Sciences Building) at Stony Brook University. Participants were recorded individually and were presented with a list of target words written in the Persian alphabet. They were asked to read each target word three times at a natural speech rate. Recordings were made using Praat (Boersma & Weenink, 2024) and saved in WAV format for subsequent acoustic analysis.

2.1 Phonetic Length Distinction in Historically Long vs. Short Vowels in MSP

To reassess conflicting findings in previous phonetic studies regarding vowel length distinctions in the pairs [a–ɑ], [e–i], and [o–u] in colloquial MSP, the first part of the production experiment was designed to evaluate the statistical significance and consistency of these distinctions. The test focused on the following phonological contexts:

1. Absolute vowel duration in unstressed open syllables (CV): This context has been highlighted in prior literature (e.g., Modarresi Ghavami, 2011, 2015) as the most favorable environment for observing phonetic length contrasts, due to the absence of coda effects and vowel reduction pressures.
2. Absolute and proportional vowel duration in unstressed closed syllables (CVC): This context has been identified in prior studies (e.g., Feshandeki & Nourbakhsh, 2012) as a robust environment for detecting vowel length distinctions, particularly when speech rate is controlled.

Since lexical stress in MSP nouns and adjectives falls on the final syllable (Samareh, 1977), all target vowels were placed in non-final (penultimate) syllables, ensuring that they were unstressed.

To ensure reliability and comparability, the experiment incorporated several methodological controls, most of which have not been systematically applied in prior work:

- Prosodic positioning: All target vowels were embedded in a falling pre-nuclear position to minimize durational variability due to pitch accent or sentence-level prominence.
- Number of syllables: Each vowel pair appeared in either disyllabic or trisyllabic words, with the target vowel consistently placed in the penultimate syllable, avoiding final lengthening effects.
- Post-vocalic environment: All target vowels were followed by a vowel of consistent quality, minimizing coarticulatory effects from the following segment.
- Speech rate control: In CVC contexts, proportional vowel duration was calculated as the ratio of vowel duration to total rhyme duration, allowing normalization across speakers and tokens.

The production stimuli consisted of 12 target words containing the six MSP vowels in open and closed syllables in pre-nuclear, unstressed positions (Table 1), along with 10 filler items. All words were embedded in the carrier sentence [asan goftam ___ hɑlɑ ce ʧi?] ‘Let’s say I said ___, so what?’, which created a naturalistic and colloquial speech context.

Table 1. Target Words Containing 6 MSP Vowels (in red) in Open and Closed Syllables

ta.miz ‘clean’	te.kɑp ‘struggle’	bo.xɑr ‘steam’
tɑ.dʒic ‘from Tajikestan’	ti.mɑr ‘caring’	bu.dɑr ‘smelly’
das.tɑn ‘hands’	bes.tun ‘debt’	bos.tɑn ‘orchard’
dɑs.tɑn ‘story’	bis.tun ‘mountain’	bus.tɑn ‘garden’

2.2 Phonological Length Distinction and Compensatory Lengthening

To investigate the phonological status of vowel length in MSP, the second part of the production experiment examined whether only historically “short” vowels ([a, e, o]) undergo significant and consistent lengthening following deletion of a glottal stop (/ʔ/), or whether historically “long” vowels ([ɑ, i, u]) exhibit similar behavior. This allows a direct test of whether a moraic asymmetry between the two vowel sets blocks lengthening in one class.

All experimental controls from the first part were maintained, including stress placement, prosodic position, syllable count, post-vocalic environment, and speech rate control. The only difference concerned the syllable type, which determined the type of durational measurement.

The stimulus set included six vowel pairings: [a–aː], [e–eː], [o–oː], [ɑ–ɑː], [i–iː], and [u–uː], where the colon-marked variants represent potential lengthened forms resulting from glottal coda deletion. Because glottal stops in coda position are frequently deleted in colloquial MSP, underlying /CVʔ/ syllables surface as [CV], identical to underlying open syllables.

All glottal coda contexts were selected based on prior descriptions (e.g., Darzi, 1991) and were independently verified through auditory and spectrographic inspection to confirm deletion in the recorded productions.

As a result, open syllables (CV) were the only measurable context in this part of the experiment. Consequently, only absolute vowel duration could be analyzed, as proportional measures require a coda consonant.

The stimuli consisted of 12 matched target word pairs (Table 2), along with 10 filler items, all embedded in the same carrier sentence.

Table 2. Target Words Containing 6 MSP Vowels (in red) with and without Underlying Glottal Coda

ta.miz ‘clean’	te.kɑp ‘struggle’	bo.xɑr ‘steam’
taʔ.bir ‘interpretation’	teʔ.dɑd ‘number’	moʔ.tɑd ‘addicted’
mo.sɑ.vɑt ‘equality’	ko.pi.sɑz ‘printer’	ne.mu.dɑr ‘chart’
de.fɑʔ.kɑr ‘defender’	mo.tiʔ.sɑz ‘obeyance’	mo.zuʔ.dɑr ‘problematic’

2.3. Data Analysis

The data gathered from the production experiment were analyzed using acoustic measurements and statistical modeling. Acoustic analysis was conducted in Praat (Boersma & Weenink, 2024), and measurements were taken to assess vowel duration in MSP across different phonological contexts.

In open syllables (CV), the absolute duration of the vowel was measured in milliseconds (ms). In closed syllables (CVC), both vowel and coda consonant durations were measured, allowing for the calculation of proportional vowel duration as the ratio of vowel duration to total rhyme duration (vowel + coda). This measure was used to control for variation in speech rate across speakers and tokens.

Vowel onset was defined as the point of periodic voicing, identifiable by the emergence of a stable formant structure in the spectrogram and waveform (typically corresponding to F1). Vowel offset was defined as the point at which this formant structure disappeared, typically marking the onset of the following consonant or silence. The coda consonant was measured from the end of the vowel formants to its acoustic endpoint (e.g., burst or closure).

Figure 2 illustrates an example of the waveform and spectrogram used for segmentation, including the labeling of vowel onset and offset for the vowels [a], [ɑ], [aː], and [ɑː]. This figure demonstrates the consistency of the segmentation criteria applied across tokens and speakers and provides a visual reference for the measurement procedure.

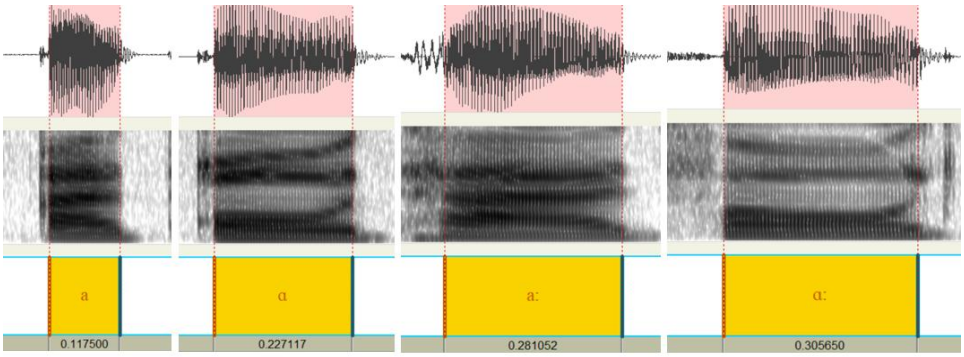

Figure 2. Waveform, Spectrogram, and Vowel Labeling: [a], [ɑ], [aː], and [ɑː]

These acoustic measurements formed the basis for statistical comparisons of vowel duration across vowel pairs and phonological contexts.

To analyze absolute duration (a continuous variable), a linear mixed-effects model was used to determine:

- whether the vowel pairs [a–ɑ], [e–i], and [o–u] exhibit significant absolute durational contrasts in CV and CVC syllables
- whether the vowel pairs [a–aː], [e–eː], [o–oː], [ɑ–ɑː], [i–iː], and [u–uː] exhibit significant absolute durational contrasts before and after glottal coda deletion (all realized as CV on the surface)

To analyze proportional duration (bounded between 0 and 1), a logit-transformed mixed-effects model was used to determine:

- whether the vowel pairs [a–ɑ], [e–i], and [o–u] exhibit significant proportional durational contrasts in CVC syllables

Mixed-effects models were used because each speaker produced multiple tokens, and therefore observations were not independent. This approach allows appropriate statistical control for speaker-level variability while maximizing the use of the available data. Statistical significance was evaluated using p-values, with $\alpha = 0.05$.

3. RESULTS

The findings from the production experiment, acoustic analyses, and statistical tests are presented in this section. First, to reassess conflicting findings in previous phonetic studies regarding length distinctions in the vowel pairs [a–ɑ], [e–i], and [o–u] in colloquial MSP, the first part of the production experiment examined phonetic length differences in these vowel pairs in terms of:

- absolute duration in unstressed open syllables (CV)
- absolute and proportional duration in unstressed closed syllables (CVC)

This study, in addition to controlling for syllable count, controlled for prosodic context, the quality of the following vowel, and speech-rate effects—factors that have not been systematically addressed in earlier phonetic research.

In pre-nuclear, unstressed CV syllables, there was a consistent and statistically significant phonetic length distinction in the vowel pairs [a–ɑ], [e–i], and [o–u], based on their absolute durations in the colloquial speech of all three native speakers of contemporary MSP (all p-values < .0001).

Figure 3 presents the mean absolute duration of each vowel, averaged across three repetitions for each of the three speakers.

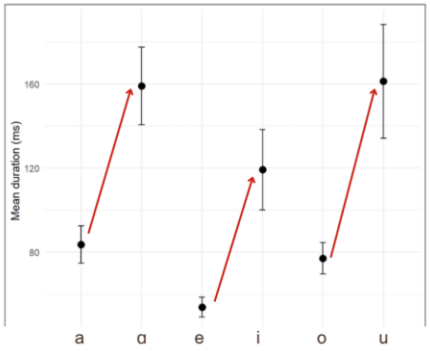

Figure 3. Absolute Durations in CV, Mean of 3 Repetitions, 3 Speaker

Similarly, in pre-nuclear, unstressed CVC syllables, there was a consistent and statistically significant phonetic length distinction across all vowel pairs [a–ɑ], [e–i], and [o–u], based on both absolute and proportional durations in the colloquial speech of all three native speakers of contemporary MSP.

For proportional duration, all vowel pairs showed highly significant differences (all p-values < .0001). For absolute duration, the contrast was also statistically significant across all pairs, with p < .0001 for [a–ɑ], p = 0.0018 for [e–i], and p = 0.0045 for [o–u].

Figures 4 and 5 present the mean absolute and proportional durations of each vowel, averaged across three repetitions for each of the three speakers.

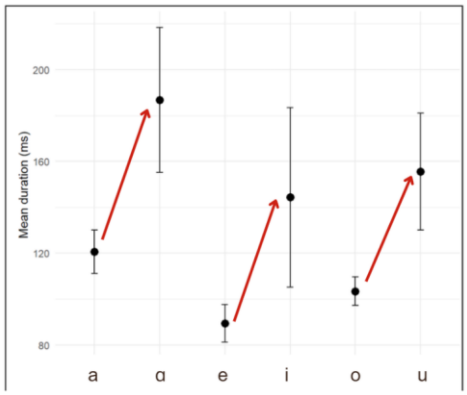

Figure 4. Absolute Durations in CVC Mean of 3 Repetitions, 3 Speaker

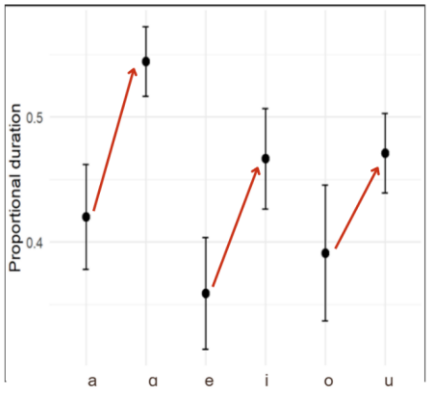

Figure 5. Proportional Durations in CVC Mean of 3 Repetitions, 3 Speaker

Furthermore, to reevaluate whether there is a significant and/or consistent phonetic length distinction between historically "short" and "long" vowels in a glottal coda deletion context, the second part of the production experiment compared the length of all six MSP vowels in contexts without an underlying glottal coda and in contexts in which a following glottal coda was deleted.

All comparisons were conducted under controlled conditions: vowels occurred in pre-nuclear position, and the quality of the following vowel was held constant. Since, in colloquial MSP, speakers consistently delete glottal stop codas, the surface realizations in both conditions were CV (i.e., /CV/ → [CV] vs. /CVʔ/ → [CV]). As a result, absolute vowel duration in pre-nuclear, unstressed open syllables was the only measurable parameter in this part of the analysis.

The length distinction in the historically short vowel pairs [a–aː], [e–eː], and [o–oː] was consistent and statistically significant across all repetitions and all three speakers, as predicted by the claim that short vowels undergo CL following glottal coda deletion (all p-values < .0001).

Crucially, the results for historically long vowels do not align with this prediction. The vowels [i] and [u] showed consistent and statistically significant length differences between non-deletion and deletion contexts, contrary to the claim that only historically short vowels undergo CL. The effect was robust for [i–iː] ($p < .0001$) and weaker but still significant for [u–uː] ($p = 0.0478$).

For [ɑ–ɑː], no statistically significant difference was found; however, length differences were consistent in direction across all repetitions and speakers.

Figures 6 and 7 present the results for historically short vowels [a, e, o] and historically long vowels [ɑ, i, u] before and after glottal coda deletion. Vowels in the deletion context are indicated by a colon (ː).

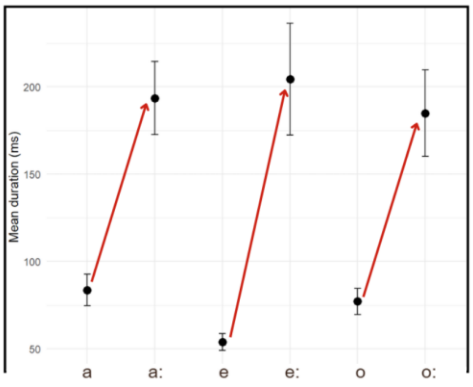

Figure 6. Absolute Durations of Historically Short Vowels before and after Glottal Coda Deletion Mean of 3 Repetitions, 3 Speaker

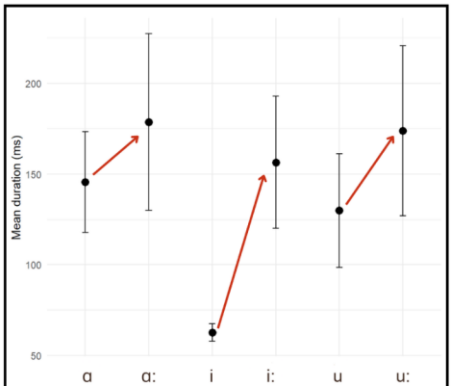

Figure 7. Absolute Durations of of Historically Long Vowel before and after Glottal Coda Deletion Mean of 3 Repetitions, 3 Speaker

These results challenge previous claims of a clear asymmetry between the two sets of historically distinct vowels, [a, e, o] vs. [ɑ, i, u], in terms of their behavior with respect to compensatory lengthening following glottal coda deletion.

4. DISCUSSION

This study examined the phonetic and phonological status of vowel length distinctions in contemporary MSP through acoustic data from three native speakers. The results of the production experiment provide new evidence regarding the role of vowel quantity in the phonological system of MSP.

The first question of this study was whether phonetic length distinctions between historically "short" vowels [a, e, o] and historically "long" vowels [ɑ, i, u] remain robust in contemporary colloquial MSP. The production experiment examined vowel length in open and closed syllables (CV and CVC), which previous studies have identified as the most favorable and second most favorable environments, respectively, for observing phonetic length distinctions (Modarresi Ghavami, 2011; Feshandeki & Nourbakhsh, 2012).

This study controlled for four factors, three of which have not been systematically addressed in prior phonetic work: (1) syllable count, (2) prosodic context (pre-nuclear position), (3) consistency in the quality of the following vowel, and (4) speech-rate effects, addressed through proportional duration in closed syllables.

The results show that in open syllables, all participants exhibited consistent and statistically significant phonetic length distinctions across all vowel pairs [a–ɑ], [e–i], and [o–u], based on absolute duration. Similar patterns were observed in closed syllables (CVC), where both absolute and proportional measures yielded consistent and statistically significant contrasts. Importantly, the patterns observed for proportional duration did not differ substantially from those found for absolute duration, supporting the validity of using absolute duration as a reliable measure in CV contexts.

Overall, these findings indicate that phonetic length distinctions remain robust across vowel pairs in contemporary MSP, aligning with a substantial body of prior research (e.g., Aronow et al., 2017; Modarresi Ghavami, 2015; Feshandeki & Nourbakhsh, 2012).

The second question addressed whether compensatory lengthening (CL) following glottal coda deletion applies exclusively to historically short vowels or more broadly across the vowel inventory. Under traditional moraic accounts, CL is restricted to historically short vowels because they are underlyingly monomoraic, whereas historically long vowels are bimoraic and therefore cannot undergo further lengthening due to a restriction against trimoraic syllables (Hayes, 1989).

The results of the production experiment, however, do not fully support this prediction. As expected, historically short vowels [a–aː], [e–eː], and [o–oː] showed consistent and statistically significant lengthening across all speakers and repetitions. Crucially, historically long vowels also exhibited lengthening. The vowels [i] and [u] showed consistent and statistically significant increases in duration in glottal coda deletion contexts, while [ɑ], although not reaching statistical significance, displayed consistent lengthening across speakers and repetitions.

The lack of statistical significance for [ɑ] may reflect phonetic ceiling effects (Nakai et al., 2009; Yuen et al., 2014), given its intrinsically longer duration in MSP, rather than a categorical phonological restriction. This interpretation is further supported by the observation that [ɑ] was consistently the longest vowel across conditions, both in this study and in previous work (Kambuzia & Hadian, 2009; Azizian & Kambuzia, 2018).

Taken together, these results challenge the assumption of a categorical asymmetry between historically short and long vowels in their behavior under CL. Rather than supporting an account in which only monomoraic vowels undergo lengthening, the findings suggest a more uniform process of vowel lengthening across the vowel inventory, albeit with variation in magnitude.

More broadly, the evidence suggests that vowel duration distinctions in contemporary MSP remain phonetically robust but are no longer governed by categorical moraic constraints. Instead, vowel length appears to be gradient, variable across speakers, and increasingly decoupled from moraic representation.

These findings support the view that the Persian vowel system is undergoing phonological reanalysis: evolving from a quantity-based system in Middle Persian to a transitional quality-and-

quantity system, and toward a system in which vowel quality plays the primary contrastive role. In this emerging system, vowel length, although still phonetically present, is no longer a reliable marker of phonological contrast across all contexts and speakers.

This shift challenges strictly moraic accounts and may reflect a broader restructuring of the prosodic system of MSP, potentially involving a gradual shift from mora-based to more syllable-based representations.

More generally, these findings contribute to ongoing debates in phonology concerning how phonetic cues are reanalyzed over time. They raise broader questions about how learners assign underlying representations to ambiguous surface forms, how formerly contrastive cues such as duration become redundant, and how phonological systems reorganize during sound change. By examining MSP at this transitional stage, this study provides insight into the interaction between phonetic variation and phonological structure and into the mechanisms through which sound change progresses.

5. CONCLUSION

This study investigated the phonetic and phonological status of vowel length and lengthening in MSP using production data from three native speakers. The results confirm that while phonetic vowel length distinctions between historically short and long vowels ([a, e, o] vs. [ɑ, i, u]) remain robust, the phonological contrast based on vowel quantity and moraic weight is weakening.

Crucially, compensatory lengthening following glottal coda deletion was not restricted to historically short vowels: all six vowels showed evidence of lengthening, although with variation in statistical strength.

Taken together, these findings suggest that MSP is undergoing a phonological shift from a quantity-based system toward one primarily organized around vowel quality. This transition challenges traditional mora-based accounts and provides new evidence for the gradual reanalysis of phonetic cues in phonological systems.

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