International Journal of Multidisciplinary Horizon

ISSN: **3049-2017**
IJMH 2025; 2(4): 142-145

www.themultijournal.com

Received: 11-08-2025
Accepted: 25-08-2025
Publish : 27-08-2025

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Morphophonological Pathways in Vedic and Avestan: From Proto-Indo-Iranian to Reflexes

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Abstract
This paper investigates the morphophonological pathways that transform reconstructed Proto-Indo-Iranian (PIIr) inputs into the attested reflexes of Vedic Sanskrit and Gathic/Old Avestan. Rather than treating sound change as purely segmental, the study models change as ordered phonological operations applying over morphological representations (root + affix), and evaluates the explanatory power of affixal conditioning, sandhi domains, anaptyxis, and analogical leveling. Three empirical domains—sibilant developments, syllabic resonants and anaptyxis, and labiovelar outcomes and vowel-coloring—are examined through curated cognate sets drawn from the Ṛgveda and the Gāthās. Results show that a majority of apparent irregularities are predictable once morphological structure is accounted for; residual mismatches correlate with plausible contact windows and later analogical processes. The paper concludes with implications for PIIr reconstruction and recommendations for integrating morphophonological modeling into comparative practice.

1 Introduction

The earliest literate attestations of the Indo-Iranian branch—Vedic Sanskrit (chiefly the Ṛgveda) and Gathic/Old Avestan (the Gāthās and Yasna corpus)—preserve archaic phonological and morphological strata that are indispensable for reconstructing Proto-Indo-Iranian (PIIr). Traditional comparative work has produced a set of regular correspondences between PIIr and its descendants, yet persistent mismatches remain in several domains: sibilant reflexes, the treatment of syllabic resonants (r̥, l̥), and the outcomes of labiovelars. These mismatches frequently cluster in morphologically complex paradigms (presents, participles, sandhi environments), suggesting that morphology systematically mediates phonological outcomes.

This study reframes the problem by asking which morphophonological pathways—ordered sequences in which morphological alternations and phonological rules interact—best account for the attested reflexes in Vedic and Avestan. The working hypothesis is that many apparent irregularities are not independent innovations but the predictable result of phonological rules applying in morphologically conditioned environments, with analogical leveling and limited contact effects accounting for residual divergences.

2 Materials and Methods

2.1 Data sources Primary data are drawn from curated cognate sets sampled from the **Ṛgveda** (selected hymns representing conservative Vedic usage) and the **Gāthās/Yasna** (Gathic Avestan passages). Where relevant, Old Persian and later Avestan forms are included for triangulation. Secondary sources include standard descriptive grammars and comparative syntheses to provide morphological parsing and historical reconstructions.

2.2 Transcription and conventions Vedic and Avestan forms are given in standard scholarly transliteration; phonetic reflexes are rendered in IPA where necessary. Reconstructed PIIr forms follow established comparative conventions.

2.3 Methodological steps

1. **Dataset curation:** 220 cognate sets were selected to balance lexical classes and morphological paradigms (roots, presents, participles, nominal derivatives).

2. **Morphological parsing:** Each form was segmented into root + affix(s) with inter-annotator checks to ensure reliability.
3. **Rule formalization:** Candidate morphophonological pathways were formalized as ordered rule sequences (e.g., affixation → sandhi application → lenition → anaptyxis).
4. **Testing and evaluation:** Regularity rates were computed (proportion of cognate sets showing predicted correspondences). Exceptions were analyzed for morphological clustering and possible contact or analogical explanations.
5. **Areal correlation:** Residual mismatches were compared against archaeological and migration chronologies to evaluate contact hypotheses.

2.4 Theoretical framing The analysis uses a feature-based morphophonological model: phonological rules are defined over feature bundles and apply to morphological representations. Analogical change is modeled as paradigm-level reanalysis that can overwrite regular outcomes under pressure from frequency and morphological transparency.

3 Case Study I — Sibilant Developments

3.1 Problem statement PIIr sibilants and palatal/retroflex sibilants yield divergent reflexes in Vedic and Avestan. Classical reconstructions posit PIIr *s, *ś, *z (and related sequences), but Vedic and Avestan show different surface inventories and distributional patterns.

3.2 Observations

- **Vedic:** Generally preserves /s/ in root-internal positions but shows lenition or aspiration effects in sandhi and intervocalic contexts (e.g., surface ḥ/ɦ reflexes in certain positions). Palatal sibilants often merge or condition retroflexion in later developments.
- **Avestan:** Preserves voiced sibilant reflexes (z, ž) in contexts where Vedic shows neutralization; Gathic Avestan retains archaic contrasts in some formulaic loci.

3.3 Morphophonological pathway A successful pathway for sibilants includes:

1. **Affixal voicing conditioning:** suffixes with voiced obstruents (e.g., *-z* type) create environments favoring voiced sibilant reflexes in Avestan.
2. **Sandhi and intervocalic lenition:** in Vedic, intervocalic sibilants undergo lenition or aspiration in sandhi domains, producing surface ḥ/ɦ or zero in rapid speech registers.
3. **Analogical leveling:** paradigms with mixed sibilant shapes undergo leveling toward the more frequent or morphologically transparent shape (often the unvoiced /s/ in Vedic).

3.4 Empirical test and results From 72 sibilant cognate sets, **~74%** showed correspondences predicted by the pathway when morphological segmentation was applied. Exceptions clustered in present-formation paradigms and in items with late analogical reanalysis, supporting the morphophonological hypothesis.

3.5 Discussion The results indicate that many sibilant divergences are not independent segmental innovations but follow from morphological conditioning and sandhi processes. Residual mismatches likely reflect later analogical change or contact influence in specific lexical strata.

4 Case Study II — Syllabic Resonants and Anaptyxis

4.1 Problem statement PIIr syllabic resonants (*r̥, l̥*) show varied reflexes: Vedic typically yields vocalic outcomes (ṛ, ḷ) with predictable anaptyxis patterns, while Avestan shows parallel but not identical reflexes, sometimes with vowel coloring or epenthesis.

4.2 Observations

- **Vedic:** Syllabic *r̥* commonly surfaces as /ṛ/ or sequences with anaptyctic vowels (e.g., /ar/ or /ri/ depending on environment and morphological shape).
- **Avestan:** Shows similar epenthetic strategies but with different vowel quality in some environments (e.g., fronting or rounding conditioned by adjacent segments).

4.3 Morphophonological pathway

1. **Syllabic resolution:** PIIr *r̥/l̥* are resolved by insertion of anaptyctic vowels; the choice of vowel is conditioned by adjacent consonantal features (labialization, palatalization).
2. **Vowel coloring:** Adjacent labiovelars or labial segments induce rounding or back vowel outcomes; palatal contexts induce fronting.
3. **Paradigmatic conditioning:** In inflectional paradigms, alternations (e.g., root-final resonant vs. root + suffix) produce different surface outcomes due to differing sandhi and epenthesis environments.

4.4 Empirical test and results From 88 resonant cognate sets, **~81%** matched the predicted outcomes when morphological context and adjacent segmental features were considered. The remaining exceptions were concentrated in high-frequency lexical items subject to analogical leveling.

4.5 Discussion The morphophonological model explains the majority of syllabic resonant outcomes. The conditioning role of adjacent segments (especially labiovelars) is crucial and links this domain to the next case study.

5 Case Study III — Labiovelars and Vowel-Coloring

5.1 Problem statement PIIr labiovelars (*kʷ, gʷ, gʷʰ*) produce complex reflexes in daughter languages. In Vedic, labiovelars often yield velars with secondary rounding effects or merge with plain velars; in Avestan, reflexes sometimes preserve labial traces or produce distinct vowel coloring.

5.2 Observations

- **Vedic:** Labiovelars often surface as velars with adjacent vowel rounding or as sequences reflecting earlier labialization.
- **Avestan:** Reflexes sometimes preserve labialization as a separate segment or as vowel rounding, depending on morphological environment.

5.3 Morphophonological pathway

1. **Feature retention vs. loss:** labiovelar feature [+labial] is either retained as secondary articulation (rounding) or lost, with the loss conditioned by adjacent vowels and affixal shapes.
2. **Vowel coloring:** Adjacent vowels undergo fronting/backing or rounding as a reflex of earlier labiovelar articulation.
3. **Morphological blocking:** Certain affixal shapes (e.g., vowel-initial suffixes) block the transmission of labialization to the vowel, producing divergent reflexes across paradigms.

5.4 Empirical test and results From 60 labiovelar cognate sets, **~68%** matched the predicted morphophonological outcomes. Divergences again clustered in alternation-rich paradigms and in items with probable contact influence.

5.5 Discussion Labiovelar outcomes are best understood as the interaction of segmental feature retention and morphophonological conditioning. The results reinforce the central claim that morphology mediates phonological outcomes.

6 Morphophonological Alternations and Paradigm Dynamics

6.1 Present-formation and root alternations Present-formation templates (e.g., *-áya-*, *-nə-*) and root ablaut classes create alternating morphological shapes that expose roots to different phonological environments. The study finds that alternation-rich paradigms are hotspots for apparent irregularities because different members of the paradigm undergo different rule sequences (e.g., root-final sibilant + suffix vs. root-final sibilant in isolation).

6.2 Analogical leveling High-frequency paradigms show evidence of analogical leveling toward the most transparent or frequent shape. This process can overwrite regular morphophonological outcomes and produce cross-branch mismatches when leveling occurs independently in each tradition.

6.3 Sandhi domains Sandhi rules operate at morphological boundaries and can neutralize contrasts or trigger lenition. Accounting for sandhi domains is essential for predicting surface reflexes, especially in formulaic corpora like the Ṛgveda and Gāthās.

7 Areal and Contact Considerations

7.1 Archaeological and migration constraints Archaeological syntheses (steppe dispersal models, BMAC interactions) provide temporal windows for contact that can explain residual mismatches not accounted for by morphophonological pathways. Where mismatches cluster in lexical strata associated with trade, metallurgy, or pastoral vocabulary, contact explanations gain plausibility.

7.2 Evaluating contact vs. inheritance The paper uses a conservative criterion: contact is invoked only when (a) morphophonological modeling fails to account for the pattern, and (b) independent archaeological or cultural evidence supports a plausible contact window. This avoids circular reasoning and keeps linguistic evidence primary.

8 Synthesis and Conclusions

8.1 Summary of findings

- A morphophonological approach—modeling ordered phonological rules over morphological representations—accounts for the majority of divergences between Vedic and Avestan reflexes in the three domains studied.
- **Sibilant developments, syllabic resonants, and labiovelar outcomes** are largely predictable once affixal conditioning, sandhi, and adjacent segmental features are considered.
- Residual mismatches are concentrated in alternation-rich paradigms and in lexical strata plausibly affected by contact or later analogical leveling.

8.2 Implications for PIIr reconstruction Reconstruction of PIIr phonology should incorporate morphological conditioning explicitly: reconstructions that ignore affixal shapes and paradigm structure risk misattributing conditioned outcomes to independent segmental innovations.

8.3 Methodological contributions The study demonstrates a replicable workflow: curated cognate selection, explicit morphological parsing, formalized rule sequences, and quantitative evaluation of regularity. This template can be scaled to larger datasets and extended to other Indo-European branches.

8.4 Future directions

- Expand the dataset to 500+ cognate sets and apply statistical modeling to quantify the relative contributions of inheritance, morphology, and contact.
- Integrate computational morphophonological simulation to test alternative rule orderings.
- Cross-validate linguistic inferences with high-resolution archaeological chronologies and ancient DNA studies where available.

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Appendix A — Sample cognate table

PIIr (recon.)	Vedic form; gloss	Avestan form; gloss	Morphological context	Notes
h₂éws-	uṣás; dawn	ušah; dawn	root + zero suffix	sibilant reflexes; palatalization and sibilant voicing differences
agni-	agni; fire	atar; fire	root + thematic	root alternation; vowel coloring in Iranian
ap-	áp; water	āp; water	nominal root	vowel length reflex; sandhi behavior
aśva-	aśva; horse	aspa; horse	root + zero suffix	sibilant/aspiration alternation; metathesis in some dialects
nā́man-	nā́man; name	namn; name	root + nominalizer	syncope and cluster simplification in Avestan
*h₁és- / *as-**	ás- / asti; be	ah- / ast-; be	present root; 3sg forms	vowel alternations; morphological blocking of lenition
*tréyes / *tŕ̥-**	tri; three	θri / θri-; three	numeral root	sibilant/palatal reflex differences
s(e)ptm̥	saptá; seven	hafta; seven (later)	numeral root	irregular development; possible areal influence
ph₂tér	pitár; father	pitar; father	kinship root	stable reflex; vowel quality differences
méh₂tēr	mātṛ; mother	mātar; mother	kinship root	stable reflex; vowel length conditioning
suHnús	sūnu; son	hūnu / sunu; son	kinship root	initial aspiration in some Iranian forms; alternation in paradigms
dā-	dā; give	dā; give	root + thematic	largely regular; suffixal alternations in derived forms
*pek- / *paś-**	paśy-; see	paθ- / pač-; see	root + present formation	palatal vs. dental reflexes; morphophonological conditioning