

From Phonetic Variation to Linguistic Divergence: A Dual-Axis Model of Historical Sound Change and Dialect Diversity in Arabic

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Article

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Posted Date: September 17th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11021610/v1>

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From Phonetic Variation to Linguistic Divergence: A Dual-Axis Model of Historical Sound Change and Dialect Diversity in Arabic

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Abstract

*This article develops a dual-axis model of how fine-grained phonetic variation can become stable sound change and, under sustained social separation, contribute to linguistic divergence. The temporal axis follows a potential pathway from gestural overlap and context-bound variation through perceptual reanalysis, social distribution, phonologization, lexicalization, and intergenerational transmission. The community-space axis represents the simultaneous availability of retention, innovation, diffusion, reversal, and standard-oriented restoration across speech communities. Arabic offers an unusually productive testing ground because a deep but phonologically underdetermined epigraphic record coexists with extensive contemporary dialect diversity and an early descriptive tradition concerned with articulation, assimilation, and tribal variation. The analysis triangulates Old Arabic epigraphy, comparative Ancient South Arabian evidence, Greek-script transcriptions of early Islamic Arabic, classical grammatical observations, descriptive dialectology, and variationist sociophonetics. Its central case is the alternation conventionally represented as *bnt* ~ *bt* and the modern forms /*bint*/ ~ /*bit*/ and /*kunt*/ ~ /*kut*/. The shared coronal closure of /*n*/ and /*t*/ makes /*nt*/ > [t:] articulatorily and perceptually plausible, but the surviving record does not establish a single uninterrupted lineage; recurrent or parallel innovation remains a serious alternative. Comparative analyses of /θ, ð/, /q/, /k/, and the historical reflexes associated with *jīm* show that phonetic proximity defines a constrained space of viable outcomes rather than a deterministic destination. Perception, lexical frequency, social meaning, mobility, contact, education, and child acquisition determine which outcome stabilizes. Contemporary dialect variation is therefore best treated as a constrained archive of historical possibilities, not as a direct chronological sequence. The model explains how cumulative phonological, morphological, syntactic, and lexical differentiation can participate in the emergence of language boundaries while rejecting the unsupported claim that all languages descend from Arabic. It concludes with explicit predictions and a research programme for acoustic, perceptual, epigraphic, social-network, developmental, and longitudinal testing.*

Keywords: Arabic dialects; sound change; coarticulation; perceptual reanalysis; phonologization; historical phonology; epigraphy; sociophonetics; intergenerational transmission; language divergence

Research highlights

1. A dual-axis model links intergenerational entrenchment to the spatial and social distribution of competing variants.
2. The /*nt*/ > [t:] pathway is strongly motivated as a recurrent process, but direct continuity between ancient and modern tokens is not assumed.
3. Modern Arabic dialects preserve alternative feature-based outcomes rather than successive stages on a single universal timeline.
4. Ancient spelling is treated as evidence about language, not as an acoustic recording; historical inference must be triangulated.
5. The model generalizes from dialect differentiation to language emergence without deriving unrelated language families from Arabic.

1. Introduction

42 Languages rarely change because speakers consciously agree to replace one sound with another. Many
43 changes begin in the low-level organization of ordinary speech: the tongue anticipates an upcoming
44 constriction, the velum closes earlier than expected, voicing extends into a neighbouring segment, or a
45 release is weakened during rapid production. Such effects are ubiquitous, gradient, and often unnoticed.
46 Most vanish without altering the lexicon or grammar. The historical problem begins when listeners
47 interpret a contextual effect as part of the intended structure of a word, reproduce it, and participate in a
48 social process through which the new interpretation becomes recurrent and learnable. Sound change is
49 therefore neither purely mechanical nor purely social. It emerges from the interaction of production,
50 perception, distribution, evaluation, and transmission (Ohala, 1993; Garrett & Johnson, 2013; Yu, 2023).

51 Arabic provides an especially revealing domain for investigating this interaction. Its record includes pre-
52 Islamic inscriptions written in several scripts, early Arabic forms represented in Greek, an early
53 grammatical tradition that described tribal variation, assimilation, *imāla*, and substitution, and a broad
54 continuum of modern vernaculars. A single historical consonant may have several synchronic outcomes:
55 /q/ may be [q], [g], or [ʔ]; /θ/ may remain [θ] or surface as [t] or [s]; /k/ may remain [k] or be realized as
56 [tʃ] or [ts]; and the historical segment associated with *jīm* may appear as [dʒ], [ʒ], [g], or [j]. These are
57 not random corruptions of a written norm. They are structured outcomes shaped by phonological
58 environment, lexical history, migration, prestige, identity, contact, education, and style (Holes, 1987,
59 2001, 2018; Al-Wer et al., 2022).

60 The central proposal is that synchronic dialect variation and diachronic sound change are different views
61 of the same causal architecture. A variable distributed across communities at one point in time may
62 reveal several outcomes that a historical segment can take. It does not, however, automatically reveal
63 their chronology. Contemporary variation is a constrained archive of historical possibilities rather than
64 a ready-made timeline. To interpret that archive, the analyst must establish the feature relations that make
65 a pathway plausible, the contexts that favour its earliest stages, the social mechanisms that select among
66 alternatives, and the independent evidence that establishes directionality.

67 The article formalizes this position as a dual-axis model. The temporal axis represents increasing
68 entrenchment across generations, from phonetic perturbation to contextual variation, social distribution,
69 phonologization, and broader structural divergence. The community-space axis represents the
70 simultaneous distribution of retention, innovation, diffusion, reversal, and standard-led restoration across
71 populations that share broadly similar articulatory capacities. The model is deliberately non-
72 deterministic. Articulatory proximity constrains the space of possible changes, but it cannot by itself
73 explain why a change actuates in one community and not another, or why a socially marked variant

74 survives despite pressure from a supralocal norm. Those questions require an account of social meaning,
75 network structure, mobility, and acquisition (Weinreich et al., 1968; Labov, 2001, 2007; Yu, 2023).
76 The argument is developed through a historically cautious comparison. The article first distinguishes
77 coarticulation, assimilation, perceptual reanalysis, phonologization, diffusion, and genealogical
78 divergence. It then specifies a hierarchy for evaluating historical pronunciation from imperfect written
79 evidence. The /nt/ > [t:] pathway is examined through the alternation bnt ~ bt and modern /bint/ ~ [bit:]
80 and /kunt/ ~ [kut:]. This case is compared with interdental reflexes, qāf, kāf, jīm, living assimilation, and
81 vowel raising. Finally, the article identifies the conditions under which dialect differentiation can
82 contribute to language emergence, while separating that legitimate generalization from the claim that all
83 languages descend from Arabic.

84 **1.1. Research problem**

85 The problem is the absence of a single explanatory framework that explicitly connects five levels often
86 treated separately: (a) similarity in place, manner, voicing, nasality, emphasis, and gestural timing; (b)
87 coarticulation, substitution, and assimilation; (c) synchronic variation across dialects and styles; (d)
88 stabilization through social repetition and child acquisition; and (e) the cumulative contribution of such
89 changes to linguistic divergence. Individual studies may describe the stopping of an interdental, the
90 urbanization of qāf, the affrication or deaffrication of kāf, or a specific spelling alternation in an
91 inscription. The theoretical need is to show how these observations can be connected without collapsing
92 phonetic plausibility into historical proof.

93 **1.2. Significance**

- 94 1. It integrates historical phonology and sociophonetics within one falsifiable framework.
- 95 2. It treats inscriptions and foreign-script transcriptions as evidence of unequal strength rather than as
96 direct recordings of speech.
- 97 3. It shows how contemporary dialect differences can represent alternative outcomes of a shared
98 historical segment.
- 99 4. It distinguishes a defensible account of language emergence from the unsupported proposition that
100 all languages derive from Arabic.
- 101 5. It translates a broad theoretical claim into measurable predictions concerning duration, voicing,
102 spectral structure, articulation, perception, age, style, and social networks.

103 **1.3. Objectives**

- 104 1. To construct a dual-axis model that explains the movement of variation from individual production
105 to community norms and from synchronic diversity to historical divergence.
- 106 2. To analyse evidence from Old Arabic, Ancient South Arabian, Safaitic, Greek-script Arabic, and the
107 early grammatical tradition without assuming that orthography fully specifies pronunciation.
- 108 3. To compare modern dialect outcomes through explicit feature preservation and alteration.
- 109 4. To assess bnt ~ bt and /bint/ ~ [bit:] as evidence for a recurrent /nt/ > [t:] process while keeping direct
110 inheritance and parallel innovation distinct.
- 111 5. To identify the role of children, peers, identity, prestige, education, mobility, and dialect contact in
112 stabilizing or reversing variants.
- 113 6. To state the conditions under which dialect differentiation contributes to the formation of a separate
114 language.

115 **1.4. Research questions**

116 *Table 1. Research questions and analytical issues*

No.	Question
1	To what extent does similarity in place, manner, voicing, or timing increase the probability of substitution between two sounds?
2	How can a context-induced phonetic effect become an independent category in the perception and production of a later generation?
3	Do contemporary dialect outcomes represent possible stages, alternative endpoints, retentions, or parallel innovations?
4	Under what conditions can spelling alternation in inscriptions support an inference about pronunciation?
5	How do phonetic constraints interact with identity, prestige, mobility, education, and interregional contact?
6	When can cumulative dialect differentiation become language divergence, and what cannot be inferred from lexical resemblance alone?

117 **2. Conceptual and theoretical framework**

118 **2.1. Coarticulation, assimilation, and phonologization**

119 Speech is temporally continuous rather than a sequence of fully independent segments. Articulatory
120 gestures overlap because the vocal tract cannot return to a neutral configuration between every sound

121 and because efficient production depends on anticipatory and perseverative coordination. A nasal
122 followed by an oral coronal stop, for example, involves two gestures that share a tongue-tip or tongue-
123 blade closure but differ in velic configuration. Variation in relative timing can shorten the audible nasal
124 interval, lengthen oral closure, or obscure the boundary between the two segments. Related timing
125 relations underlie place assimilation, palatalization, voicing assimilation, and emphasis spread.

126 Coarticulation is not itself a historical sound change. It is a recurring source of structured phonetic
127 variation. Garrett and Johnson (2013) distinguish biases arising from motor planning, aerodynamics,
128 gestural mechanics, and perceptual parsing. Such biases explain why certain pathways recur and why
129 some changes are directionally favoured. They do not explain why most coarticulatory effects remain
130 stable allophones while a minority becomes lexicalized or phonologized. The analytical distinction
131 between a phonetic precursor and a historical change is therefore fundamental.

132 Assimilation is the increase of similarity between neighbouring segments. It may be partial, as when a
133 nasal adopts the place of a following stop but retains nasality, or complete, as when one segment loses
134 its independent cues and the following segment is lengthened. It can affect place, manner, voicing,
135 nasality, or secondary articulation. Phonologization occurs when a formerly predictable phonetic effect
136 becomes represented as part of the linguistic system through a new contrast, a rule, a stable lexical form,
137 or a morphologized alternation (Blevins, 2004; Beddor, 2009).

138 **2.2. Perceptual reanalysis**

139 Listeners do not observe the movement of the tongue or velum directly. They infer linguistic categories
140 from an acoustic signal in which neighbouring gestures are superimposed. In familiar contexts, listeners
141 often compensate for coarticulation by discounting an effect attributable to an adjacent segment. Under-
142 correction occurs when the listener fails to remove the contextual contribution and stores the affected
143 realization as part of the target. Hypercorrection is possible when more than the contextual effect is
144 removed. Ohala (1993) treats these perceptual decisions as a major source of sound change, while
145 Beddor (2009) demonstrates how coarticulatory relations can support a transition from gradient variation
146 to categorical reorganization.

147 Perceptual reanalysis need not be an error in any ordinary sense. It is a rational interpretation of a signal
148 with overlapping causes. A listener who hears a short or weak nasal murmur followed by a long coronal
149 closure may reasonably analyse the sequence as a geminate stop. A learner exposed to many such tokens
150 may construct a distribution in which the assimilated form is not an occasional reduction but a
151 conventional realization. The historical consequence arises when this analysis is reproduced, socially
152 circulated, and acquired by new speakers.

153 **2.3. Transmission, diffusion, and social selection**

154 A phonetic innovation does not become a community change merely because it is easy to produce or
155 easy to misperceive. It must recur within a social ecology. Weinreich, Labov, and Herzog (1968) framed
156 this as the problem of embedding and actuation: innovations occur in linguistic systems and social
157 structures, and researchers must explain why a potential change becomes active at a particular time and
158 place. Yu (2023) similarly treats actuation as a problem at the intersection of individual differences,
159 cognitive processing, interaction, and population dynamics.

160 Labov (2007) distinguishes transmission within a community from diffusion between communities.
161 Transmission occurs when children acquire a structured local system and may increment changes beyond
162 caregiver rates. Diffusion often spreads an externally salient form while weakening the detailed structural
163 conditioning that characterized it in its source community. This distinction is essential for Arabic, where
164 urbanization, education, labour migration, media exposure, and the presence of a prestigious written
165 standard can all redistribute variants.

166 Social evaluation can support either innovation or retention. A phonetically conservative realization may
167 spread because it indexes education or formal competence. An innovative realization may persist because
168 it indexes urban identity, local authenticity, gendered style, or membership in a dense network.
169 Conversely, a historically local feature may retreat under supralocal pressure. The same articulatory
170 possibility can therefore have different historical outcomes in different communities.

171 **2.4. Intergenerational articulatory drift**

172 The term intergenerational articulatory drift is used here as an analytical label for the accumulation of
173 small differences in the realization of a segment until its distribution is reorganized and stabilized in a
174 word, construction, or dialect. The label does not imply that change is always slow or linear, nor that it
175 is transmitted exclusively from parents. Innovations may accelerate through peer networks, educational
176 institutions, media, mobility, or contact. The defining point is that a stable realization in a later generation
177 is no longer an episodic imitation; it belongs to the production and perception system through which
178 speakers automatically organize speech.

179 **2.5. Core hypotheses**

- 180 ❖ The smaller the articulatory and perceptual distance between two outputs, the greater the probability
181 of alternation, other factors being equal; this is a probabilistic tendency, not a deterministic law.

- ❖ A change usually preserves at least one major feature place, manner, voicing, nasality, or timing while reorganizing another. Thus /θ/ > [t] and /θ/ > [s] preserve different subsets of the source features.
- ❖ Innovation commonly begins in a restricted phonological, prosodic, morphological, or lexical environment before spreading more widely.
- ❖ Synchronic dialect variation is a living archive of possible historical outcomes, but it does not identify the oldest outcome without independent evidence.
- ❖ Child acquisition is guided by the distributions and social meanings available in family, peer, and community input; pronunciation is culturally learned, not genetically inherited.
- ❖ A separate language emerges only through cumulative differentiation across multiple linguistic levels combined with durable social separation, contact history, standardization, and institutional development

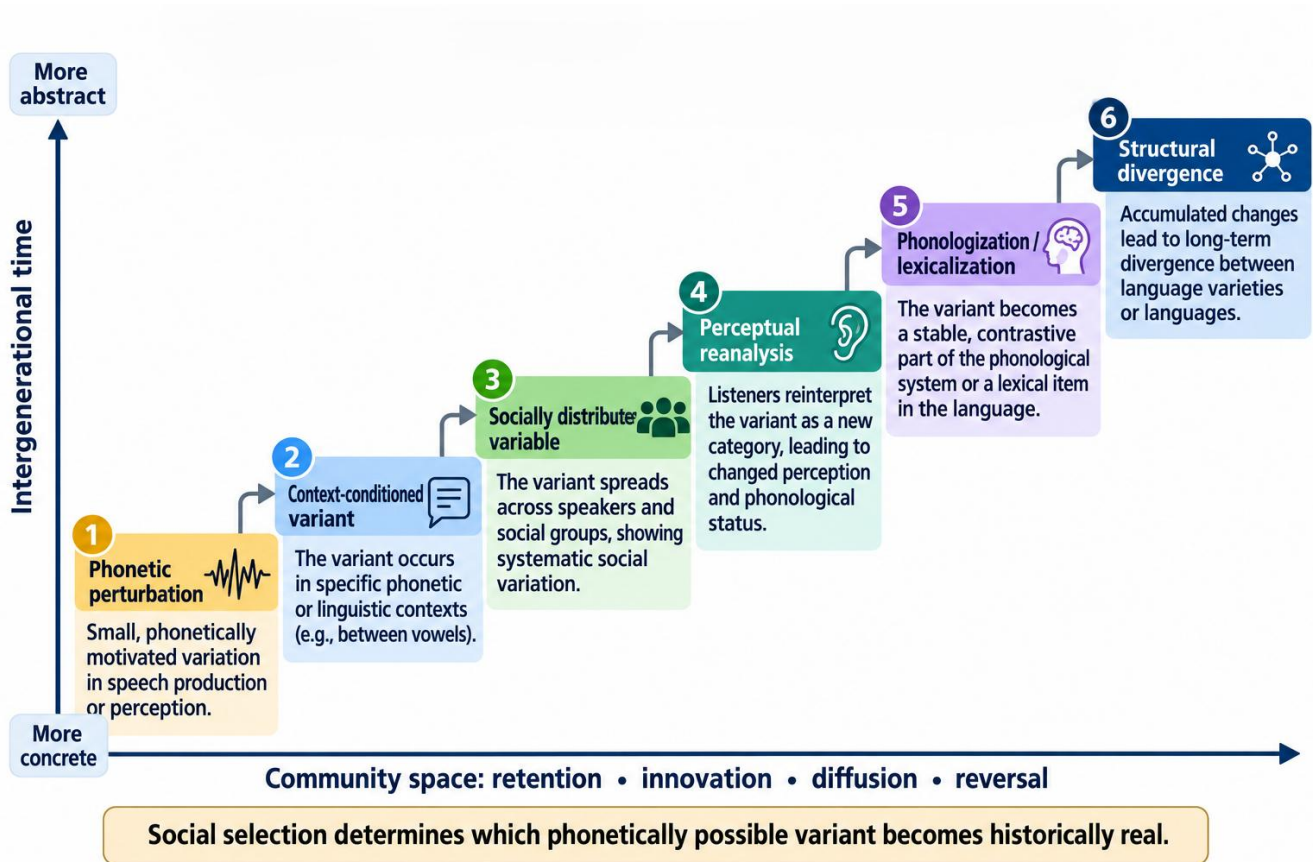
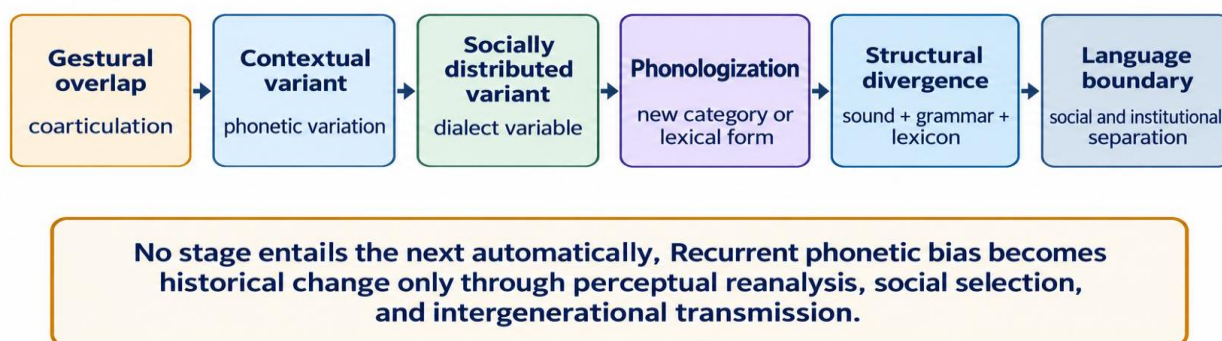


Figure 1. The dual-axis model of sound change. (The vertical axis represents increasing intergenerational entrenchment; the horizontal axis represents the distribution of retention, innovation, diffusion, and reversal across communities. Original figure prepared for this study).

From articulatory movement to linguistic divergence



198

199 **Figure 2. A probabilistic progression from articulatory movement to linguistic divergence.** (No step
200 entails the next automatically. A phonetic precursor becomes a historical change only when perceptual, social, and
201 intergenerational conditions converge. Original figure prepared for this study).

202 3. Methodology and limits of inference

203 3.1. Study design and evidence base

204 This is an integrative theoretical and historical study rather than an experiment involving newly recruited
205 participants. It synthesizes four evidence classes: (1) Old Arabic and related epigraphic traditions,
206 including Safaitic and early Arabic inscriptions; (2) comparative Ancient South Arabian material, used
207 as parallel Semitic evidence rather than as an assumed ancestor of Arabic; (3) Greek-script and other
208 cross-script representations of early Arabic that provide information absent from consonantal
209 orthographies; and (4) descriptive and experimental studies of modern Arabic dialects, including
210 sociophonetic research on variation and change.

211 Each case was analysed according to the proposed earlier form, the later or contemporary output, shared
212 and altered features, preceding and following environments, possible intermediate realizations,
213 geographic distribution, social and stylistic distribution, chronological evidence, and competing
214 explanations. The competing explanations include retention, innovation, contact-induced borrowing,
215 lexical diffusion, analogical restructuring, and parallel development. Where the evidence does not
216 establish direct descent, the conclusion is explicitly restricted to process similarity or historical
217 plausibility.

218 The study follows a uniformitarian principle: articulatory and perceptual mechanisms observable in
219 living speech can inform the interpretation of historical patterns. Uniformitarian reasoning does not
220 imply linear continuity. The existence of /nt/ > [t:] in a modern dialect proves that the process is humanly

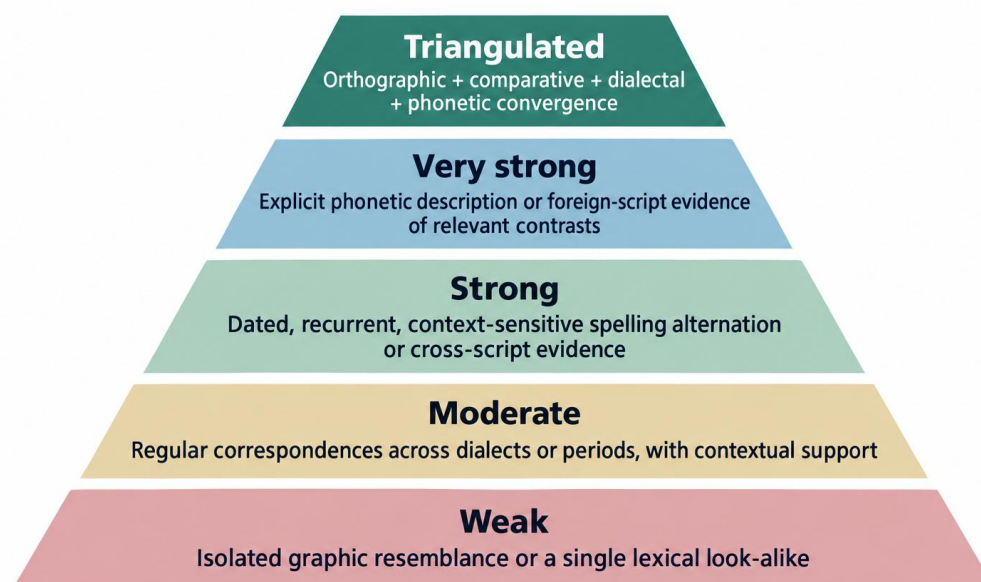
221 and linguistically possible; it does not prove that a modern token directly descends from a particular
222 ancient spelling. Direction and genealogy require independent historical evidence.

223 **3.2. Why Ancient Writing Is Not Enough**

224 Ancient scripts are indispensable linguistic evidence, but they are not acoustic records. Many Arabian
225 scripts are primarily consonantal and do not consistently represent short vowels, stress, fine allophony,
226 gradient nasalization, or the exact duration of closure. A written consonantal skeleton can identify a
227 lexical or morphological pattern without determining whether a vowel was [a], [e], or [i], whether a
228 consonant was partly assimilated, or whether a sequence contained a perceptually weak segment.
229 Orthographic omission may reflect phonetic reduction, scribal economy, abbreviation, graphic
230 convention, morphological analysis, or damage. A single spelling cannot discriminate among these
231 possibilities. The historical argument becomes stronger when an alternation recurs across writers,
232 locations, or periods; is concentrated in a plausible phonological environment; corresponds to an
233 independent dialectal or comparative pattern; and is supported by a script that marks contrasts omitted
234 by the local orthography. Greek-script Arabic is particularly valuable because Greek letters can constrain
235 vowel quality and certain consonantal distinctions, although the transcription remains filtered through
236 Greek phonology and spelling (Al-Jallad, 2017).

237 ***Table 2. Hierarchy of evidence for historical pronunciation***

Rank	Evidence type	Value and limitation
A	Explicit phonetic description or foreign-script transcription	Closest to pronunciation because it records a contrast absent from the local script; still filtered through the describing language.
B	Recurrent, dated, context-sensitive spelling alternation	Strong support for a sound process when distributed across writers, places, or periods; may still reflect convention or morphology.
C	Regular correspondences across dialects, stages, and paradigms	Supports reconstruction when broad, semantically coherent, and morphologically integrated; direction may remain uncertain.
D	Consonantal and semantic similarity in one lexical item	May motivate a hypothesis of continuity or relationship; does not recover full pronunciation.
E	Surface resemblance without regularity or an intermediate history	Weak evidence; vulnerable to coincidence, borrowing, and selective comparison.



Ancient orthography is evidence about language, but it is not an audio recording.

Figure 3. Hierarchy of evidence for historical pronunciation. (Ancient orthography is evidence about language, but it is not an audio recording. Original figure prepared for this study.)

3.3. Criteria for evaluating a proposed pathway

- 1) Articulatory feasibility: Can the output arise from known gestural overlap, aerodynamic pressure, or feature timing without an implausible movement?
- 2) Perceptual feasibility: Does the acoustic signal permit more than one reasonable causal parse?
- 3) Contextual regularity: Is the variant favoured in a predictable phonological, prosodic, morphological, or lexical environment?
- 4) Social distribution: Do age, gender, education, style, mobility, network structure, or locality predict usage?
- 5) Chronology: Are the relevant forms dated or ordered through an external comparator?
- 6) Comparative integration: Does the proposal participate in regular correspondences and paradigms rather than isolated resemblance?
- 7) Alternative explanations: Can borrowing, analogical change, orthographic convention, retention, or parallel innovation explain the same pattern?

Table 3. Articulatory features of the principal sounds

Segment	Place	Manner	Voicing	Relevance to change
---------	-------	--------	---------	---------------------

/n/	Coronal/alveolar	Nasal sonorant	Voiced	Homorganic with /t, d/; can assimilate in place or lose independent nasal cues.
/t/	Coronal/alveolar	Oral stop	Voiceless	Near /θ/ in anterior place and near /d/ in all features except voicing.
/d/	Coronal/alveolar	Oral stop	Voiced	A frequent outcome of /ð/ when frication is replaced by complete closure.
/θ/	Interdental/dental	Fricative	Voiceless	Can become [t] while preserving anterior place or [s] while preserving frication.
/ð/	Interdental/dental	Fricative	Voiced	Can become [d] or [z] through alternative feature-preserving pathways.
/q/	Uvular	Stop	Usually voiceless	Reflexes [q, g, ʔ] involve changes in place and/or laryngeal setting and are densely social.
/k/	Velar	Stop	Voiceless	Fronting and palatalization can produce [tʃ] or [ts], especially near front vowels or in selected morphemes.
Historical jīm-related segment	Palatal/alveopalatal or velar, by reconstruction	Affricate, fricative, stop, or approximant	Voiced	Reflexes [dʒ, ʒ, g, j] require branch-specific historical analysis rather than a single recent chain.

255 *Note. Places are approximate because actual articulations vary across communities and speakers.*

256 4. The historical pathway: from inscription to reconstructed pronunciation

257 4.1. Pre-Islamic Arabia was not linguistically uniform

258 The linguistic landscape of pre-Islamic Arabia and the southern Levant contained multiple languages,
259 scripts, and dialect continua. Ancient South Arabian includes Sabaic, Minaic, Qatabanic, and
260 Hadramitic; these are related Semitic languages, not simply early dialects of Arabic. Safaitic and Hismaic

261 inscriptions represent varieties conventionally classified within Old Arabic or its immediate epigraphic
 262 environment, but they too display internal diversity. Script identity must be separated from language
 263 identity: Arabic material may be written in a script derived from Nabataean, while a script tradition can
 264 serve more than one linguistic variety (Macdonald, 2000; Al-Jallad, 2015, 2021). This diversity is
 265 theoretically important. It rules out the image of a single, homogeneous spoken Classical Arabic from
 266 which every modern dialect descended through an identical path. Classical Arabic is a highly
 267 consequential codified variety, but the history of Arabic also includes vernacular lineages, contact zones,
 268 and features that may connect modern varieties to epigraphic layers without passing through the standard
 269 as a spoken ancestor in a simple linear sequence (Owens, 2006, 2023; Al-Jallad, 2021, 2026).
 270 The archaeological images included below document the depth and diversity of the written record. They
 271 do not directly prove a specific phonetic realization. Their analytical role is to show what kind of
 272 evidence survives and why phonetic reconstruction must combine material, orthographic, comparative,
 273 and modern data.



274

275 **Figure 4. Ancient South Arabian building inscription from Yemen, third century CE.** (Photograph by
 276 Osama Shukir Muhammed Amin, via Wikimedia Commons, CC BY-SA 4.0. The object illustrates the Ancient
 277 South Arabian written record; it is not claimed to be the specific token containing bnt or bt discussed below).

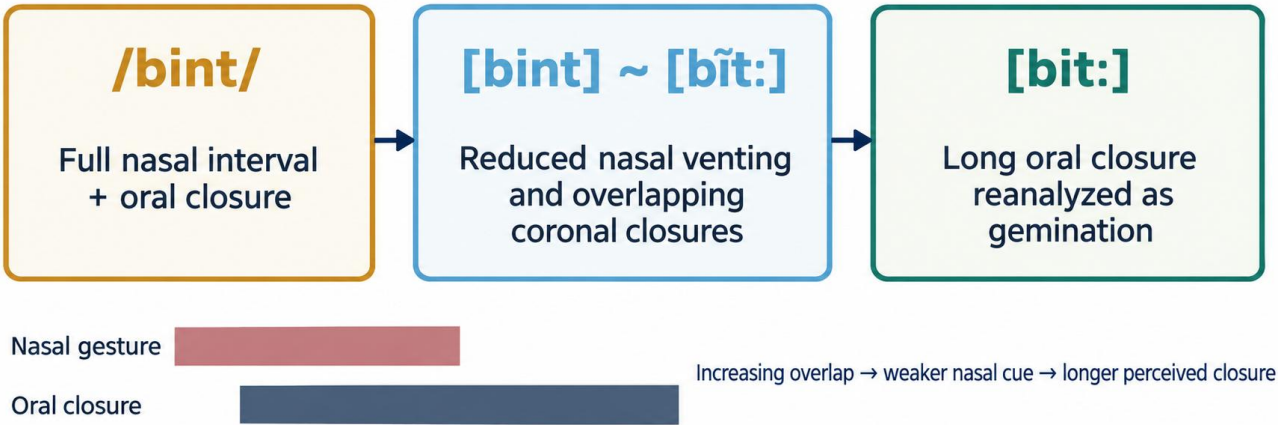
278 4.2. The central case: bnt ~ bt and /nt/ > [t:]

279 The spelling alternation conventionally summarized as bnt ~ bt, together with comparable patterns of n-
 280 loss or assimilation before coronal consonants in Ancient South Arabian descriptions, provides a central
 281 test case. Modern Arabic varieties also display forms such as /bint/ ~ [bit:] “girl/daughter” and /kunt/ ~

282 [kut:] “I/you were,” and complete assimilation of /n/ to a following /t/ has been described in dialects of
 283 eastern Arabia and elsewhere (Watson, 2002, 2014). The recurrence of the pattern makes random
 284 consonant deletion an insufficient general explanation.

285 The articulatory pathway is direct. /n/ and /t/ are homorganic coronals: both use an anterior tongue
 286 closure, while they differ principally in velic state, oral airflow, voicing, and release. In careful /nt/, nasal
 287 airflow and voicing identify /n/ before the oral stop. In faster or more overlapping production, the velum
 288 may close earlier, the nasal murmur may shorten, voicing may cease, and the oral closure may lengthen.
 289 An acoustic result with weak nasal cues and a long closure can be perceptually assigned to [t:]. The
 290 process is therefore not an arbitrary substitution of one letter for another; it is a reorganization of the
 291 timing of closely coordinated gestures.

292 Three claims must remain separate. First, /nt/ > [t:] is phonetically plausible. Second, recurrent bnt ~ bt
 293 spellings are compatible with assimilation or gemination when their distribution is regular. Third, a
 294 specific modern form does not automatically descend from a specific ancient inscription. Geographic
 295 distance, chronological gaps, and incomplete intermediate evidence leave open a wider regional feature,
 296 recurrent innovation, lexical diffusion, and parallel development. This restraint strengthens rather than
 297 weakens the model: if similar outputs recur independently, the human speech system contains historical
 298 attractors without determining a single genealogy.



The pathway is phonetically plausible, not a claim that every modern [t:] directly descends from a specific ancient spelling.

299

300 **Figure 5. A gestural pathway from /nt/ to [t:].**

301 Increasing temporal overlap shortens the nasal cue and lengthens oral closure. The pathway is
 302 phonetically plausible; it does not claim that every modern token descends directly from a specific
 303 ancient spelling. Original figure prepared for this study.

304 **4.3. Safaitic evidence and the plurality of Old Arabic**

305 Safaitic inscriptions are distributed across the basalt desert of southern Syria, northeastern Jordan, and
306 northern Arabia. They record names, genealogies, movement, pastoral activity, prayers, conflict, and
307 personal commemoration. Their linguistic importance lies not in representing an imperfect version of
308 the later standard but in documenting an Old Arabic variety or cluster of varieties in its own social
309 ecology (Al-Jallad, 2015).

310 Safaitic orthography is economical and largely consonantal. It can establish the presence of roots, affixes,
311 lexical patterns, and recurrent consonantal alternations, but it does not fully specify short vowels, stress,
312 allophonic duration, or gradient assimilation. The strongest analysis therefore identifies distributions
313 rather than reading every written letter as a transparent segment. A recurrent bnt ~ bt pattern is stronger
314 than an isolated omission; a geographically and morphologically conditioned pattern is stronger than a
315 unique spelling; and convergence with independent phonetic processes is stronger than visual similarity
316 alone.



317
318 **Figure 6. Safaitic inscription and rock drawing from Jordan.** (Photograph by Osama Shukir Muhammed
319 Amin, via Wikimedia Commons, CC BY-SA 4.0. The image illustrates the material character of Safaitic
320 evidence and does not necessarily depict the specific bt spelling).

321 **4.4. The Namārah inscription and the limits of monumental evidence**

322 The Namārah inscription, dated to 328 CE, is a major witness to Arabic written in a Nabataean-derived
323 script and to the political and linguistic history of late antique northern Arabia. Its value lies in its date,
324 morphology, lexicon, formulaic structure, and relation to later Arabic. It also demonstrates that Arabic
325 history did not begin with Islamic manuscripts.

326 Yet the monument does not encode a complete phonetic transcript. The Nabataean-derived script does
327 not consistently mark short vowels or all details of consonant realization. The inscription must therefore
328 be analysed alongside comparative Semitic morphology, other inscriptions, and later Arabic evidence.
329 The lesson is methodological: an artefact can be historically decisive while remaining phonetically
330 underdetermined.

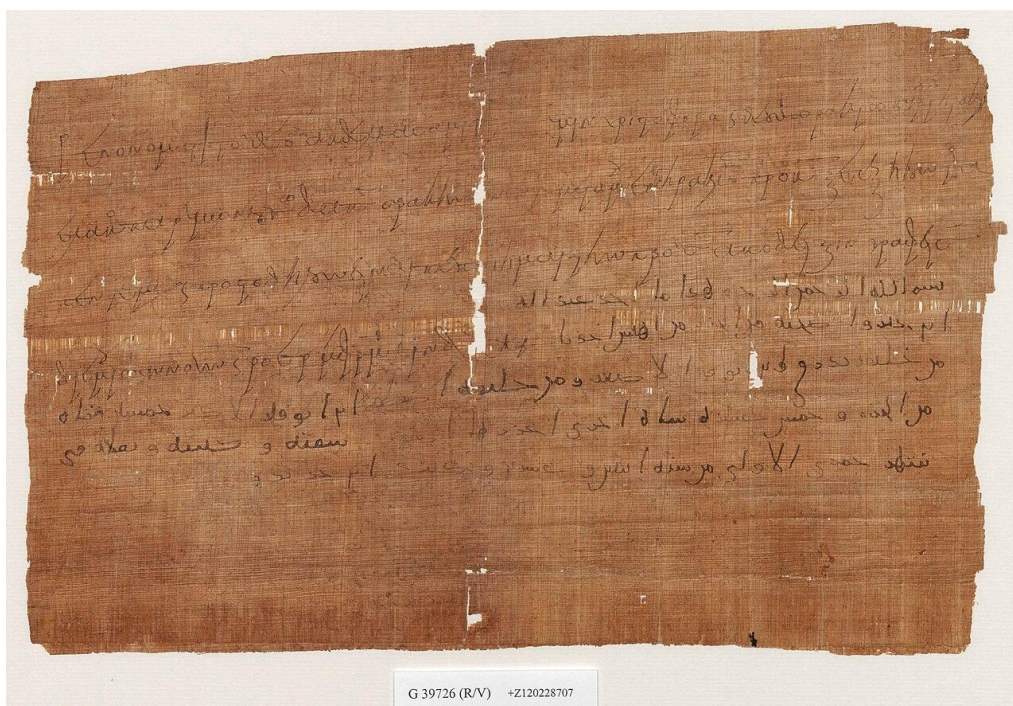


331

332 **Figure 7. The Namārah inscription, epitaph of Imru' al-Qays ibn 'Amr, dated 328 CE.** (Photograph
333 by Marie-Lan Nguyen, Louvre Museum AO 4083, via Wikimedia Commons; public domain).

334 4.5. Greek transcriptions and the recovery of vowel quality

335 Greek-script transcriptions of Arabic from the first Islamic century are especially valuable because Greek
336 represents vowels more explicitly than the Arabic consonantal script of the period. Such transcriptions
337 can reveal vowel raising, reduction, and the quality of proper names and lexical items. They cannot be
338 read mechanically: Greek orthography and phonology constrain the options available to the writer, and
339 names may be adapted to Greek morphological patterns. Nevertheless, repeated spellings provide an
340 independent window on early Arabic phonology (Al-Jallad, 2017). Forms reconstructed from these
341 materials, including patterns such as /šərīk/, /səlīm/, /yəzīd/, /gəmlāh/, and fronted or raised vowels in
342 relevant environments, support the existence of vowel reduction and imāla-like processes outside the
343 later prescriptive vocalization. These data matter to the present model because they demonstrate a
344 pathway from context-sensitive phonetic tendencies to conventional dialect outcomes and because they
345 show how an external script can strengthen an inference that local orthography leaves open.



346

347 **Figure 8. PERF 558, an Early Bilingual Papyrus Containing Greek and Arabic.** (Image via
 348 Wikimedia Commons; public domain. Cross-script documents provide information about early Arabic
 349 that is absent from consonantal spelling alone).

350 **Table 4. Selected Indications from Greek-Script Arabic**

Reconstructed form	Arabic equivalent	Analytical significance
/šarīk/	šarīk “partner”	Reduction or raising of /a/ before stressed /ī/ in a CaCīC-type structure.
/səlīm/	salīm “sound; proper name”	Comparable raising or reduction in a similar prosodic structure.
/yəzīd/	Yazīd	A mid or raised unstressed vowel before the stressed syllable.
/gəmilah/	Jamīlah	The pattern can affect feminine names and interacts with syllable structure.
/ziyād/	Ziyād	Fronting or raising of long /ā/ in a phonologically defined environment.
/mēlek/	Mālik or malik, depending on context	An external script constrains vowel quality while lexical and morphological analysis remains necessary.

351 *Note. The forms summarize patterns discussed in cross-script research and should not be interpreted as a single*
 352 *uniform early Arabic vocalism.*

353 **Table 5. Epigraphic and historical examples relevant to sound change**

Evidence	Period/material	Possible process	Strength of inference
bnt ~ bt	Safaitic; with parallel Semitic evidence	Assimilation of /n/ to /t/ or graphic representation of a geminate	Strong when recurrent; does not establish direct descent into one modern dialect.
'nfs ~ 'fs	Middle or Late Sabaic, in comparative descriptions	Loss or assimilation of /n/ before a following consonant	Moderate to strong depending on distribution and scribal independence.
'ntt ~ 'tt	Sabaic	Assimilation of /n/ before /t/	Supports the same general process family.
Raising of /a/ before /ī/	Greek transcriptions from the first Islamic century	Vowel assimilation, reduction, or prosodically conditioned raising	Relatively strong because the external script marks vowels, with transcriptional limitations.
Diversity represented by Safaitic and Namārah	Old Arabic epigraphy	Pre-standard dialect differentiation and non-identity with the later codified norm	Contextual evidence that variation predates standardization.

354 *Note. Ancient South Arabian is used comparatively; it is not treated as an ancestor or dialect of Arabic.*

355 **4.6. The Arabic grammatical tradition as phonetic evidence**

356 Early Arabic grammarians classified consonants by points and manners of articulation and described
 357 assimilation, substitution, imāla, emphasis, and tribal variants. Sībawayh and later Ibn Jinnī repeatedly
 358 related alternations to proximity of articulation and ease of transition. These descriptions are
 359 methodologically important because they provide explicit metalinguistic observations from a period
 360 much closer to the relevant varieties than modern reconstruction. The grammatical tradition nevertheless
 361 has its own goals and categories. It is oriented toward recitation, correctness, morphology, and the
 362 analysis of prestigious or transmitted speech. A statement about “closeness of articulation” is not an
 363 acoustic measurement, and a listed tribal form may not describe its frequency or social distribution. The

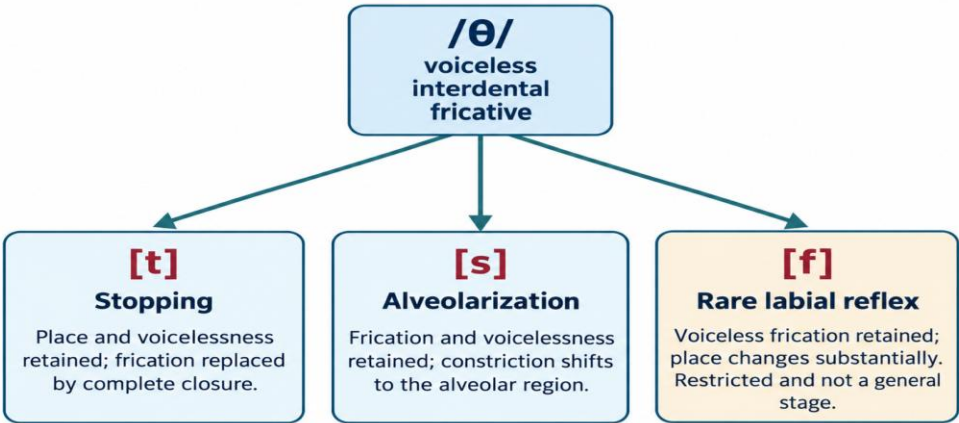
364 most productive use of the tradition is therefore triangulation: traditional observations motivate a
365 phonetic hypothesis that can be compared with inscriptions, dialects, and modern instrumental analysis.

366 **5. Contemporary Arabic dialects: synchronic variation as living history**

367 **5.1. Interdentals: preserving place or preserving manner**

368 Historical /θ/ and /ð/ provide a clear demonstration that one source can support more than one structurally
369 coherent outcome. Retention as [θ] or [ð] preserves place, manner, and voicing. Stopping to [t] or [d]
370 replaces frication with complete closure while preserving anterior place and voicing status. Sibilant
371 reflexes [s] and [z] preserve frication and voicing status while shifting the constriction toward the
372 alveolar region. A rare [f] reflex preserves voiceless frication but changes place more radically and must
373 not be treated as a general stage (Al-Essa, 2022; Youssef, 2021).

374 The alternatives show why the phrase “the sounds are close” is insufficient. The analyst must ask which
375 dimension is close and which feature is retained. Egyptian forms commonly represented as talāta, ti’īl,
376 and tōb illustrate /θ/ > [t]; forms such as dahab, dirā‘, and dēl illustrate /ð/ > [d]. Sibilant outcomes may
377 be lexically or regionally stratified. Learned borrowings from Standard Arabic can reintroduce
378 interdentals into words that otherwise follow the dialect pattern, creating within-speaker and within-
379 lexicon variation. Interdental variation also illustrates social selection. Retention may index Bedouin,
380 rural, regional, or formal orientations in one community, while stopping may be locally unmarked or
381 urban in another. The same phonetic form can therefore carry different social values. Historical
382 explanation requires local social history rather than a universal ranking of conservative and innovative
383 dialects.



The outcomes are alternatives, not a universal chronological sequence.

384

385 **Figure 9. Alternative feature-preserving pathways for historical /θ/.** (The branches are possible
386 outcomes, not successive stages in a universal chronology. Original figure prepared for this study).

Source	Outcome	Illustrative forms	Feature preserved	Comment
/θ/	[θ]	thalaatha-type retention	All major features	Common in many Bedouin and Peninsular varieties; not restricted to one social meaning.
/θ/	[t]	talāta, ti`īl, tōb-type forms	Anterior place and voicelessness	Stopping; common in Egyptian and other urban varieties.
/θ/	[s]	Sibilant outcomes in selected varieties or lexical strata	Voicelessness and frication	Constriction shifts to the alveolar region; often lexically conditioned.
/θ/	[f]	Restricted Bahraini or regional reflexes reported in the literature	Voicelessness and frication	Rare; should not be generalized beyond documented contexts.
/ð/	[ð]	dhahab-type retention	All major features	Retention in numerous varieties.
/ð/	[d]	dahab, dirā‘, dēl-type forms	Voicing and anterior place	Stopping with complete closure.
/ð/	[z]	z-type outcomes in selected words and varieties	Voicing and frication	May be stratified by lexicon, borrowing, or style.

388 *Note. Romanized examples are illustrative and do not imply identical phonetic detail across all dialects.*

389 **5.2. Qāf: a phonological variable with dense social meaning**

390 Few Arabic consonants demonstrate the limits of purely articulatory explanation more clearly than qāf.
391 Its major reflexes include [q], [g], and [ʔ], with additional local outcomes. All three can function as stops,
392 but they differ in place and laryngeal configuration. The articulatory system makes these outputs
393 possible; it does not assign their social meanings. In one community [q] may index formal speech,
394 education, or alignment with Standard Arabic; [g] may index Bedouin, tribal, rural, masculine, or local
395 identity; and [ʔ] may index an urban centre. In another community the distribution is different. Speakers
396 often style-shift among variants, and lexical items borrowed from the standard may preserve [q] in

397 otherwise [g]- or [ʔ]-using speech. The variable is therefore simultaneously phonological, lexical,
398 stylistic, and social.

399 Apparent-time evidence from Arabic communities shows that age differences must be interpreted
400 cautiously. A difference between older and younger speakers may represent community change, age
401 grading, lifespan change, migration, or stylistic reallocation. Real-time recordings and family-peer
402 designs are needed to distinguish these possibilities.

403 **5.3. Children Reconstruct Community Patterns**

404 Research on Syrian Arabic variation demonstrates that children do not simply reproduce the token
405 frequencies of each parent. They respond t

406 o community-wide distributions, gendered patterns, peer norms, and changing social meanings. Habib
407 (2017), for example, shows that parent-child relationships in variable language require more than a direct
408 copying model. Work on vowel variation similarly illustrates that younger speakers may reverse or
409 reorganize a pattern as they locate themselves socially (Habib, 2014). These findings support the
410 transmission component of the dual-axis model. Pronunciation is learned through distributions of
411 exemplars embedded in social relationships. A child can acquire a community pattern even when it
412 differs from one caregiver, and adolescents may intensify peer-group norms. Intergenerational
413 transmission is therefore reconstruction under social constraints rather than genetic inheritance of a
414 phonetic habit.

415 **5.4. Kāf: Palatalization, Affrication, and Dialect Leveling**

416 In dialects of the Gulf, Najd, and Iraq, /k/ may be realized as [tʃ] or [ts] in selected phonological and
417 morphological environments, frequently in association with front vowels or particular suffixes. A
418 plausible phonetic pathway begins with anterior displacement and palatalization [kʲ], followed by an
419 affricated release. The exact conditioning differs across communities, and the outcome may become
420 morphologized or lexicalized (Holes, 1991; Watson, 2002). Instrumental work on Emirati Arabic
421 identifies phonological conditioning in the variability of affricated and lenited realizations and shows
422 that neighbouring segments can affect the probability of a variant (Szreder & Derrick, 2024). The Qaṣīm
423 case demonstrates social reversal or leveling: older and less educated speakers may retain a local
424 affricated realization, while younger, more educated speakers especially women in the reported
425 community move toward supralocal [k] (Al-Rojaie, 2013). The example displays several model stages
426 within one society: an older contextually motivated innovation becomes a local emblem and later retreats
427 under regional standardization.

428 **5.5. Jīm: Retention, Affrication, Deaffrication, and Weakening**

429 The Arabic letter jīm corresponds to [dʒ], [ʒ], [g], [j], and other local realizations. Some relations are
430 phonetically transparent: [dʒ] > [ʒ] can be analysed as loss of the stop phase, and [dʒ] > [j] as further
431 weakening. The relation of Egyptian [g] to [dʒ], however, cannot be reduced to a simple recent change
432 from the standard affricate. Comparative Semitic and Arabic dialect history permit analyses in which [g]
433 reflects retention of an older stop in one branch while affrication developed in another (Woidich & Zack,
434 2009; Youssef, 2021). This case warns against arranging dialects on a moral or chronological scale. A
435 form that appears “colloquial” may be conservative in one feature, while a standard-like form may be an
436 innovation or restoration in another. The correct question is not which dialect is purer but which
437 historical operations and contact histories account for each reflex.

438 ***Table 7. Selected Realizations of Qāf, Kāf, and Jīm***

Variable	Selected outcomes	Phonetic mechanism	Social/historical conditioning
qāf	[q], [g], [ʔ]	Changes in posterior place, voicing, and/ or relocation of stop closure to the glottis	Urban-rural and tribal histories, formal standard, gender, style, education, and contact.
kāf	[k], [tʃ], [ts], and restricted [ʃ]-like outcomes	Palatalization/fronting followed by affrication or frication	Front-vowel environment, morphology, age, education, gender, and dialect leveling.
jīm-related historical segment	[dʒ], [ʒ], [g], [j]	Affrication, deaffrication, weakening, or branch-specific retention	Regional history, standard competition, lexical borrowing, and contact.

439 *Note. No single linear chain is assumed for all jīm reflexes.*

440 **5.6. Living assimilation and feature spreading**

441 The early phases of sound change are observable in present-day Arabic. In min ba‘d “after,” /n/ may
442 adopt labial place before /b/ and be realized as [m], reflecting early lip closure. The definite article /al-/
443 assimilates before the traditional “sun letters,” as in /al-šams/ > [aʃ:ams], where the lateral loses its
444 independent realization and the following coronal is lengthened. In the historical morphology of Form
445 VIII, emphasis and voicing may spread to /t/, as conventionally illustrated by iṣṭabara and iḏṭaraba-type
446 forms. These processes demonstrate that Arabic routinely reorganizes sequences into more coordinated

447 gestures. A process can remain allophonic, become morphophonological, lexicalize in particular words,
 448 or be reanalysed as a property of a morpheme. The living rules do not prove the history of every ancient
 449 form, but they define mechanisms that historical analyses must consider.

450 **Table 8. Living Assimilation and Coarticulatory Processes in Arabic**

Input	Approximate output	Process	Relation to the model
/bint/	[bit:] in selected dialects	Complete assimilation of /n/ to /t/	A contextually motivated pathway can become lexical or dialectal.
/min ba‘d/	[mim ba‘d] or an assimilated nasal	Nasal place assimilation /n/ > [m] before /b/	Anticipatory lip closure produces a living phonetic precursor.
/al-šams/	[aš:ams]	Assimilation of the definite-article /l/	Complete coronal assimilation with gemination.
/ʃ+t/ in Form VIII	[ʃt]-type outcome	Emphasis spread and reclassification of /t/	A gradient articulatory effect becomes a stable morphophonological pattern.
/d+t/ in Form VIII	[dt]-type or related outcome	Assimilation in emphasis and laryngeal features	Coordination reduces conflict between gestures.
/k/ near front vowels	[tʃ] or [ts] in selected varieties	Palatalization and affrication	A phonological environment can become a dialect emblem.

451 *Note. Surface forms vary across dialects and speech rates; the table classifies mechanisms rather than prescribing*
 452 *one pronunciation.*

453 **5.7. Vowels, Imāla, and Gradient Fronting**

454 Coarticulation is not restricted to consonants. A low vowel /a/ can be raised or fronted near /i/, /ī/, or /j/,
 455 providing a phonetic basis for many imāla patterns. Early grammarians described imāla and its tribal
 456 distribution, and Greek-script Arabic provides evidence for raising before a high front vowel. Modern
 457 dialects display continua from [a] through [e] toward [i], conditioned by stress, syllable structure,
 458 consonantal environment, morphology, and local identity. Vowels occupy continuous acoustic spaces.
 459 Small differences in tongue height and advancement can accumulate, be socially evaluated, and form
 460 separate categories. The vowel evidence therefore parallels the consonantal cases: phonetic continuity
 461 does not prevent categorical historical outcomes, but the outcome is constrained by perceptual
 462 distributions and social transmission.

463 **5.8. Variation within the individual speaker**

464 A community does not always select one categorical output. A speaker may use [q] in reading or formal
465 presentation and [ʔ] or [g] in spontaneous conversation. Interdentals may occur in learned Standard
466 Arabic words while stopped reflexes occur in inherited vernacular vocabulary. This style shifting and
467 lexical stratification can persist for generations. It matters historically because change may advance word
468 by word, construction by construction, or style by style rather than applying instantaneously to the entire
469 lexicon. Probabilistic distributions are therefore often more informative than categorical substitution
470 lists.

471 **6. The dual-axis model: time and community**

472 **6.1. The temporal axis**

473 The temporal axis begins with low-awareness gestural variability. A variant is then favoured in a context
474 for example, /k/ near a front vowel or /n/ before homorganic /t/. Recurrent exposure permits perceptual
475 reparsing and lexical association. The distribution may then be phonologized, morphologized, or
476 generalized. If children acquire it as part of the community grammar and increase its frequency, the
477 change becomes intergenerational. The sequence is not obligatory or strictly linear. Contact can reverse
478 a change, education can restore a standard-oriented form in formal styles, and lexicalized residues can
479 survive after a productive rule disappears.

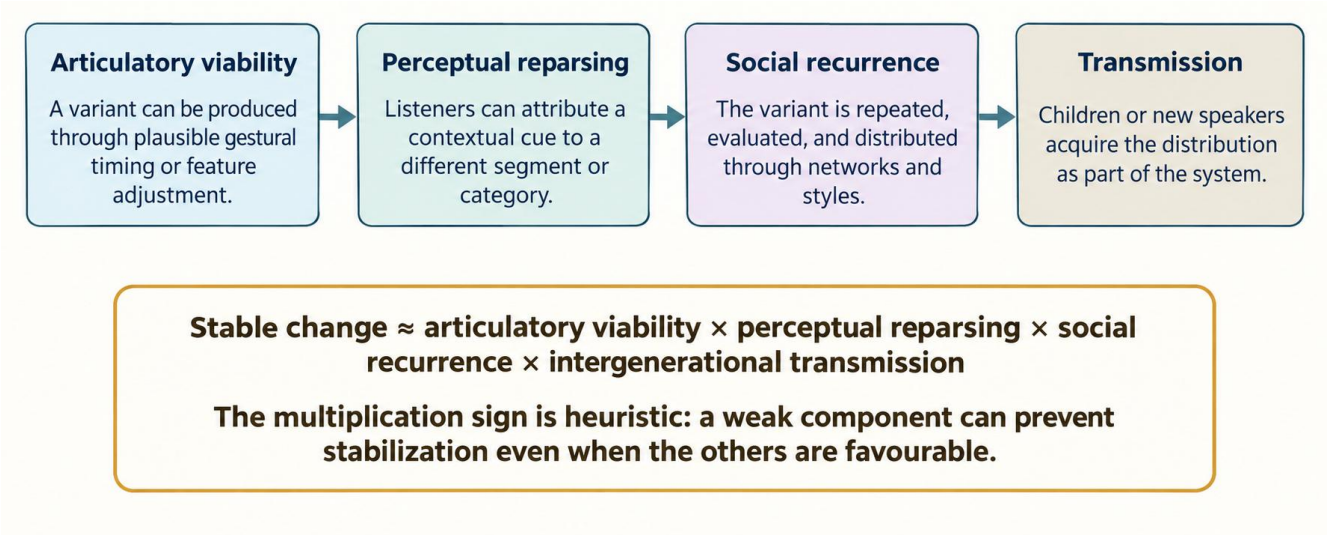
480 **6.2. The social-spatial axis**

481 At the same historical moment, one community may retain the inherited segment, a second may innovate,
482 a third may borrow the innovation from a prestigious centre, and a fourth may reverse a local change
483 under supralocal pressure. Geographic variation is therefore a cross-section through a branching history.
484 Qāf illustrates that structurally comparable variants can acquire opposite social values. [q] may be
485 conservative, formal, or restored; [g] may be local and authentic; [ʔ] may be urban and mobile. These
486 values, not ease of articulation alone, determine diffusion and persistence.

487 **6.3. A component model of stabilization**

488 The model proposes four necessary analytical components: articulatory viability, perceptual reparsing,
489 social recurrence, and intergenerational transmission. Articulatory viability makes an output available;
490 perceptual reparsing permits a new structural analysis; social recurrence gives the variant sufficient
491 frequency and meaning; and transmission integrates the distribution into the system of new speakers.
492 The components may be weighted differently in different changes, but omitting one produces an
493 incomplete explanation. The relation can be expressed heuristically as a multiplicative model: a variant

494 that is easy to produce but socially stigmatized may retreat; a socially valued variant that is not learned
 495 as part of the phonological system may remain stylistic; an orthographic form that is institutionally
 496 prestigious may be restored in formal contexts without replacing the vernacular distribution. The
 497 equation is not a numerical claim. It is a reminder that sound change is a conjunction of constraints rather
 498 than a single causal force.



499

500 **Figure 10. A component model of stable sound change.** (The multiplication sign is heuristic rather than
 501 statistical. A weak component can prevent stabilization even when the others are favourable. Original figure
 502 prepared for this study).

503 **Table 9. Predictions of the Dual-Axis Model**

Prediction	Expected observation	Illustration
Feature proximity increases substitution probability	Competing outputs usually share place, manner, voicing, or gestural timing.	/θ/ > [t] preserves anterior place; /θ/ > [s] preserves frication.
Innovation begins in a conditioning environment	The innovative realization is concentrated near a favouring segment, morpheme, or prosodic position.	/k/ > [tʃ] near front vowels or in selected suffixes.
Diffusion weakens original conditioning	A socially salient output appears in words or contexts less favourable to its phonetic origin.	A local marker generalizes after regional diffusion.
Children reconstruct the distribution	Child usage follows community, peer, and gender patterns rather than	Syrian qāf and vowel variation.

	reproducing each parent's token percentage.	
Comparable outputs can recur independently	The same pathway appears in separated periods or communities without a demonstrated contact chain.	/nt/ > [t:] in ancient evidence and living dialects.
Orthographic irregularity alone is insufficient	Historical inference strengthens with repeated, dated, context-sensitive distribution and external support.	Recurrent bnt ~ bt is stronger than one unexplained omission.

504 *Note. Each prediction can be evaluated through historical, acoustic, perceptual, developmental, or sociolinguistic*
505 *evidence.*

506 **7. From Pronunciation Differences to the Emergence of a Separate Language**

507 **7.1. What the Model Supports**

508 Historical linguistics supports the general principle that dialects can diverge until they are conventionally
509 and structurally treated as separate languages. Communities begin with related systems; regular changes
510 accumulate in phonology, morphology, syntax, lexicon, semantics, and discourse. When mutual
511 interaction declines and separate acquisition norms, identities, literary practices, and institutions develop,
512 mutual intelligibility may decrease and separate-language classification becomes appropriate. The
513 dialect-language distinction is therefore not purely phonetic. It is historical, structural, social, political,
514 and institutional.

515 Maltese offers a relevant case. It developed historically from Siculo-Arabic, underwent prolonged
516 contact with Sicilian, Italian, and English, and emerged as an autonomous standardized language written
517 in the Latin alphabet (Borg & Azzopardi-Alexander, 1997; Brincat, 2011). Sound change was part of
518 this history, but pronunciation alone did not create Maltese. The outcome required sustained separation,
519 extensive contact-driven restructuring, independent literacy, codification, and institutional functions.
520 The dual-axis model generalizes the mechanism of branching: small differences can accumulate and be
521 socially selected until neighbouring systems become structurally and institutionally distinct. It does not
522 predict when a political community will label a variety a language, nor does it reduce the distinction to
523 one threshold of intelligibility.

524 **7.2. What the model does not support**

525 The existence of phonetic similarity or transformability does not demonstrate that all languages descend
526 from Arabic. Arabic belongs to the Semitic branch of Afroasiatic and is historically related to Hebrew,

527 Aramaic, Akkadian, and other Semitic languages through ancestors reconstructed by the comparative
528 method. Arabic is not the direct mother of its sister languages. Indo-European, Sino-Tibetan, Niger-
529 Congo, Austronesian, and other families have separate comparative histories.

530 Genetic relationship requires systematic sound correspondences across substantial basic vocabulary,
531 shared morphological paradigms, reconstructable innovations, and a plausible chronology and
532 geography. Resemblance between a few words can result from chance, borrowing, sound symbolism,
533 infant-directed forms, or universal phonetic tendencies. A proposed relationship that selects only
534 matching words and ignores mismatches is methodologically unfalsifiable.

535 The defensible conclusion is more significant than an untestable universal ancestry claim: Arabic
536 provides a rich, historically layered laboratory for examining how phonetic variation becomes dialect
537 differentiation and how cumulative differentiation can contribute to language branching. The mechanism
538 can be generalized; the genealogical source must be established independently.

539 **Table 10. Conditions Contributing to Dialect-to-Language Divergence**

Condition	Contribution	Sufficient alone?
Regular sound change	Increases phonological distance and alters lexical forms.	No.
Morphological and syntactic restructuring	Rebuilds paradigms, agreement, constituent order, and grammatical expectations.	No.
Lexical replacement and borrowing	Reduces transparency and aligns branches with different contact ecologies.	No.
Sustained geographic or social separation	Reduces shared input and promotes independent acquisition norms.	Powerful, but not sufficient by itself.
Contact with different languages	Pushes branches toward different phonological and grammatical systems.	Accelerating, but not sufficient.
Independent standardization, writing, and institutions	Stabilizes norms, assigns a language name, and expands autonomous functions.	Often socially decisive.
Cumulative interaction across time	Produces broad structural, communicative, and sociopolitical differentiation.	Closest to a sufficient complex of conditions.

540 **8. Discussion**

541 **8.1. Do the cases support the model?**

542 The cases strongly support the mechanical component of the model. The alternating sounds are not
543 randomly distributed in phonetic space. /n/ and /t/ are homorganic coronals; /θ/ becomes [t] or [s] through
544 the preservation of different features; /ð/ behaves correspondingly with [d] and [z]; /k/ palatalizes in
545 fronting environments; and emphasis spreads to adjacent consonants. These processes are observable in
546 contemporary speech and are documented descriptively, instrumentally, or historically. The same cases
547 reject a deterministic account. Not every nearby sound changes, and not every change moves toward the
548 output that seems mechanically simplest. A community may reverse an innovation under standard
549 pressure, select a relatively marked output as an identity signal, or import a prestigious urban variant.
550 Two questions must therefore remain separate: Why was the variant possible? Why did it become
551 socially successful? Phonetics contributes to the first; sociolinguistics, contact history, and political
552 economy contribute to the second.

553 **8.2. Synchronic Variation as a Mirror of History**

554 When reflexes such as [θ], [t], and [s] coexist across dialects, the analyst observes several viable solutions
555 to the same feature structure. Intermediate phonetic states, lexical restrictions, style shifting, and age
556 distributions can be measured in the present and used to formulate hypotheses about historical pathways.
557 Conversely, inscriptions and cross-script transcriptions can help distinguish modern retention from
558 innovation. This reciprocal method requires cooperation between dialectology, epigraphy, experimental
559 phonetics, and sociolinguistics. Modern dialects should not be treated as noise around Classical Arabic,
560 and ancient inscriptions should not be treated as transparent vocalized texts. Each evidence type resolves
561 limitations of the other.

562 **8.3. Continuity versus parallel development**

563 The bnt ~ bt pattern is exemplary. Its similarity to modern [bit:] is attractive as evidence of continuity,
564 yet geography and chronological gaps prevent a direct lineage claim without intermediate
565 documentation. The most conservative conclusion is that the process is documented in ancient and
566 modern settings and may have been a broad areal tendency, a retained local feature, or an independent
567 innovation more than once. Parallel development does not weaken the theory. Recurrent outcomes
568 demonstrate that shared articulatory and perceptual constraints generate historical attractors across
569 communities.

570 **8.4. Proto-languages and comparative generalization**

571 Because dialects can arise from fine phonetic differences and diverge, it is legitimate to generalize the
572 branching mechanism to the formation of language families. The generalization must be mechanistic

rather than genealogically arbitrary. It explains how branches can form; it does not identify Arabic as the universal ancestor. Proto-languages are inferred through regular correspondences, shared innovations, and comparative reconstruction. Framed in this way, the model is compatible with established historical linguistics and contributes an Arabic case study with unusual historical and synchronic depth.

9. Analytical findings

Table 11. Summary of Analytical Findings

Finding	Principal evidence	Confidence
Articulatory proximity channels change but does not determine it.	Patterns /θ/-[t]-[s], /ð/-[d]-[z], and /nt/-[t:].	High.
Coarticulation can become a stable category through perceptual reanalysis.	Ohala’s model, Beddor’s coarticulatory pathway, and bnt ~ bt.	High as a general mechanism; direct lineage remains unproven.
Contemporary dialects display alternative historical outcomes.	[q, g, ʔ], [k, tʃ, ts], and [dʒ, ʒ, g, j].	High.
Children acquire socially structured distributions rather than parental tokens alone.	Syrian qāf and vowel studies.	High in the communities studied.
Consonantal orthography underdetermines full pronunciation.	Properties of Old Arabian and early Arabic scripts.	High.
Foreign-script transcription improves reconstruction of vowels and contrasts.	Greek-script Arabic of the first Islamic century.	Relatively high, with adaptation constraints.
Dialect differentiation can contribute to separate-language emergence.	General principles of change and the historical development of Maltese.	High as a general principle.
The evidence does not support derivation of all languages from Arabic.	Requirements of the comparative method and established language-family classification.	Decisive.

9.1. Theoretical Contribution

581 The principal contribution is the integration of four levels into one explanatory relation: the body
582 produces a variant, the listener reparses it, the community assigns it a distribution and social meaning,
583 and the child or new speaker reconstructs the system. The temporal and community-space axes allow
584 historical change and contemporary diversity to be treated as different sections through this causal
585 architecture. The model also introduces an evidential discipline. Articulatory plausibility is not historical
586 proof; orthographic resemblance is not phonetic identity; and modern similarity is not direct descent. A
587 robust explanation must specify both the phonetic pathway and the historical route by which a form
588 could have been transmitted. This separation permits strong general claims about recurrent mechanisms
589 while preventing unsupported genealogies.

590 **10. Applied implications**

591 **10.1. Teaching Arabic sounds and dialects**

592 The model supports non-stigmatizing teaching of Arabic dialects. Forms such as talāta, dahab, 'alb, and
593 galb are not random failures to reproduce the standard; they reflect regular phonological and social
594 histories. Learners can be taught to predict correspondences from features while also recognizing lexical
595 exceptions, learned standard forms, and style shifting. This approach improves dialect comprehension
596 and avoids treating multilingual Arabic competence as defective monolingualism.

597 **10.2. Historical lexicography and language technology**

598 A historical Arabic lexicon can link roots to epigraphic spellings, cross-script forms, dialect reflexes,
599 and graded correspondence rules rather than relying on graphic identity. Speech-recognition and text-to-
600 speech systems can use feature matrices to anticipate confusions and mappings such as /θ/-[t]-[s] and
601 /q/-[g]-[ʔ]. Such systems should model probabilistic conditioning by word, style, speaker, and region
602 instead of reducing dialects to fixed replacement lists.

603 **10.3. Identity, documentation, and language policy**

604 Supralocal variants do not spread solely because they are easier. They often carry institutional or social
605 value. Language planning and dialect documentation should therefore record local phonetic systems
606 across age groups and styles before they recede. Vernacular features are historical evidence and cultural
607 resources, not obstacles to Standard Arabic. Ethical documentation must also avoid assigning greater
608 authenticity or intelligence to one reflex over another.

609 **11. Limitations**

610  There are no audio recordings of epigraphic stages; vowel quality, stress, fine emphasis, and gradient
611 overlap must be reconstructed probabilistically.

- 612 ✚ Dialect evidence is geographically and lexically uneven, and many speech communities remain
613 underdocumented.
- 614 ✚ Standard Arabic, literacy, migration, and borrowing can reintroduce forms and obscure the inherited
615 vernacular trajectory.
- 616 ✚ This article presents a theoretical synthesis rather than a new statistical test or participant dataset.
- 617 ✚ The bnt ~ bt case does not establish a direct genealogical line from Safaitic or Ancient South Arabian
618 evidence to modern Egyptian or other dialects.
- 619 ✚ The dialect-language distinction is shaped by institutions and identity and cannot be reduced to a
620 single intelligibility percentage.
- 621 ✚ Rare proposed outcomes, including /θ/ > [f] in restricted environments, require finer fieldwork before
622 broad generalization.
- 623 ✚ The dual-axis model is a mid-range explanatory framework. It identifies components and predictions
624 but does not assign universal numerical weights to them.

625 12. Conclusion

626 This study has shown that similarity in place of articulation, manner, voicing, nasality, and gestural
627 timing explains a substantial part of the pathways available to Arabic sounds. Change can begin as an
628 unconscious overlap of gestures, become a context-conditioned variant, be perceptually reanalysed,
629 circulate through a social group, and be acquired by children as the ordinary pronunciation. The bnt ~ bt
630 alternation and the living forms [bit:] and [kut:] provide a strong case for understanding how /nt/ can
631 yield [t:], while the possibility of parallel development must remain open.

632 Contemporary dialects support the model more broadly. Interdentals, qāf, kāf, and jīm do not have one
633 inevitable reflex. They branch according to the features retained by each community and according to
634 local social history. Synchronic diversity is therefore a living archive of possible history. The vocal tract
635 does not select the historical winner alone: perception, identity, prestige, contact, education, mobility,
636 lexical frequency, and acquisition convert a phonetic possibility into a social fact. The mechanism can
637 legitimately be extended from dialect change to language emergence. Small changes, when accumulated
638 with morphological, syntactic, lexical, and pragmatic restructuring under sustained social separation, can
639 produce distinct languages. That principle does not entail that all languages descended from Arabic. The
640 stronger and more precise conclusion is that Arabic with its epigraphic depth, early analytical tradition,
641 and living dialect diversity is an exceptional laboratory for studying the route by which speech moves
642 from a gesture in the mouth to a boundary between languages.

643 **Declarations**

644 Funding: This research received no external funding.

645 Conflict of interest: The author(s) declare no conflict of interest.

646 Ethics statement: Not applicable to the present study.

647 Data availability: No new dataset was generated.

648 **References**

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