

Conditions for Japanese lexical-pitch accents to change from a complex to a simpler state.

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Introduction

The ancestral form of the Japanese accent systems existed in Kyoto at least as early as in the Heian period (794-1185), with both **word tone*** and **pitch changes***. Today, however, we see the variation of accent patterns as shown in Figure 1.

What factors maintain tone and pitch?
How are they lost?

To find this out, we analyze the followings,

1. Estimation of the rate at which accents lose complexity
2. Reconstruction of the phylogenetic tree of accent system over mainland Japan

word tone: frequency forms indicated by the high and low sounds of the whole word.
pitch changes: Where the pitch changes when words are separated by moras or syllables

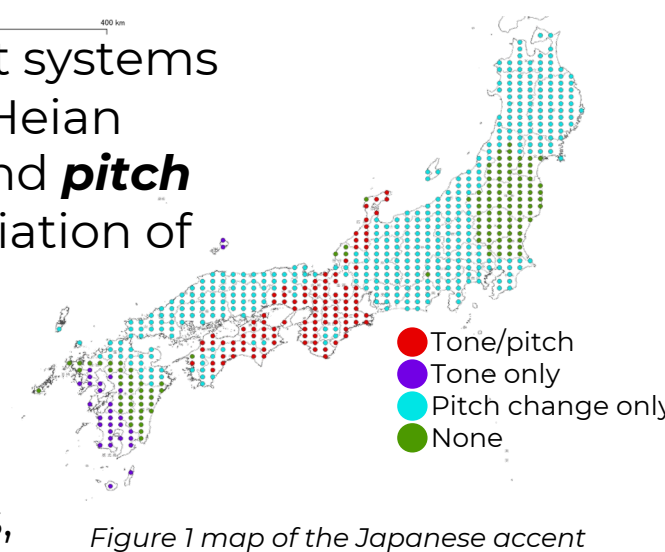


Figure 1 map of the Japanese accent

Materials & Methods

1. Spatial data of empirical accent patterns

- We use a map based on Kindaichi (1977), updated with new information (Figure 1).
- We focus on the presence/absence of **pitch accent (PA)** and **word tone (WT)**.
- The variation of accent patterns is analyzed by a four-state model where the ancestral state has both **PA** and **WT** (Figure 2).

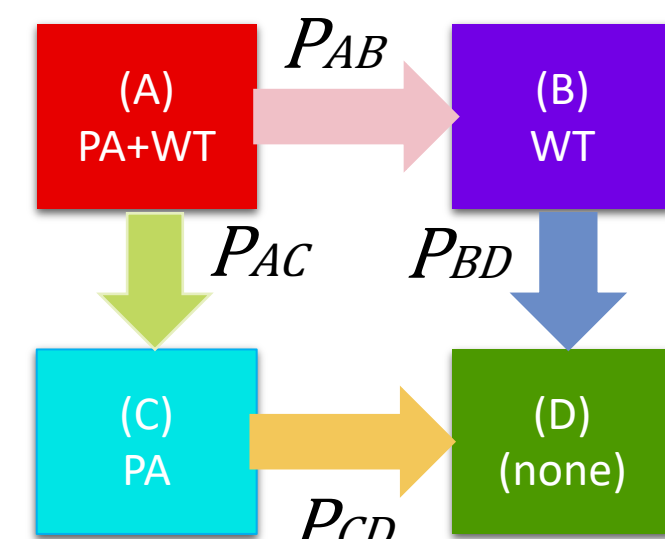


Figure 2 4-state model and mutation rates among accent patterns.

2. Geographic Procedures

- We generate a 20 km square mesh network for the Japanese archipelago (691 mesh points).
- Accent patterns are assigned to each **mesh point** to construct empirical data (*D*) on the spatial variation of accents (Figure 1)

3. Model for Phylogenetic Reconstruction

- Each **mesh point** is regarded as a population from P_1 to P_{691} .
- In each generation, every population (1) copies the accent pattern from a population. (**transmission**) (2) replaces the inherited accent pattern with another state. (**mutation**)
- In the **transmission** event, population P_i copies the accent pattern from P_j with probability $a_{ij} \propto \pi_j \exp\left(-\frac{d_{ij}^2}{200}\right)$.
- In the **mutation** event, every population loses tone and pitch change with the probabilities shown in Figure 2.
- We perform Bayesian MCMC to obtain the posterior distributions of mutation rates P_{AB} , P_{AC} , P_{BD} , and P_{CD} .
- We also sample phylogenetic trees of the 691 mesh points from the posterior distribution and visualize the inferred phylogeny using the maximum clade credibility (MCC) tree.

π_j : population density d_{ij} : geographical distance [km]

Results

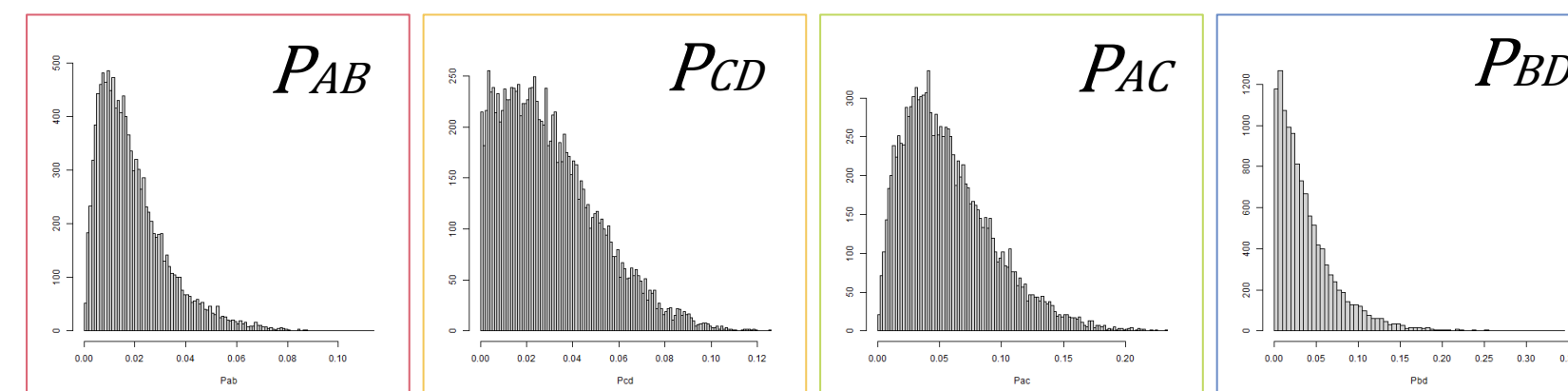


Figure 3 Posterior distribution of mutation rate (per generation)

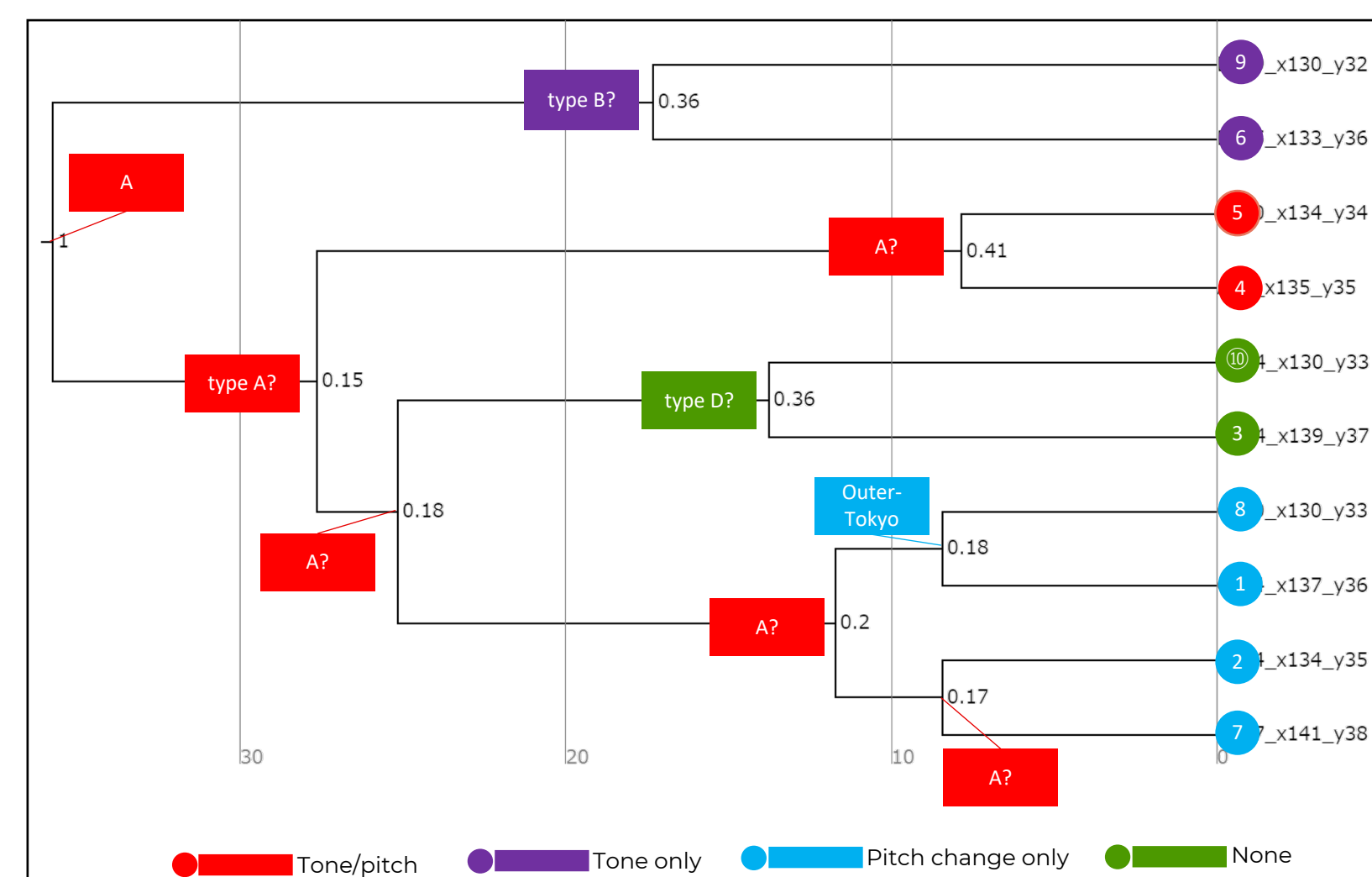


Figure 4 The Maximum Clade Credibility tree from the posterior trees
The numbers in the circles specify ten representative points chosen from the 691 mesh points. The same numbers are used in Figs 5 (Except 11 and 12) and 6.

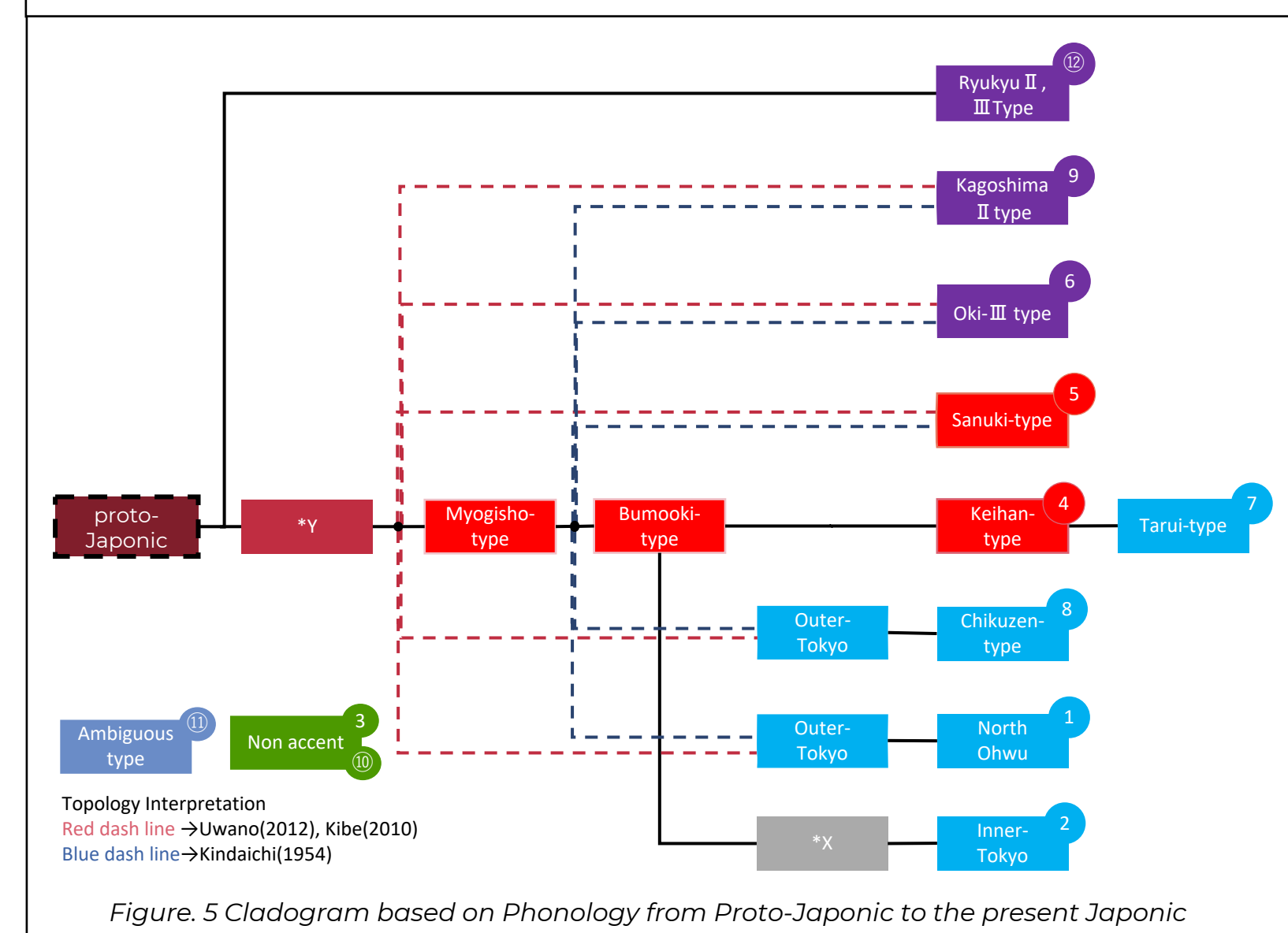


Figure 5 Cladogram based on Phonology from Proto-Japonic to the present Japonic

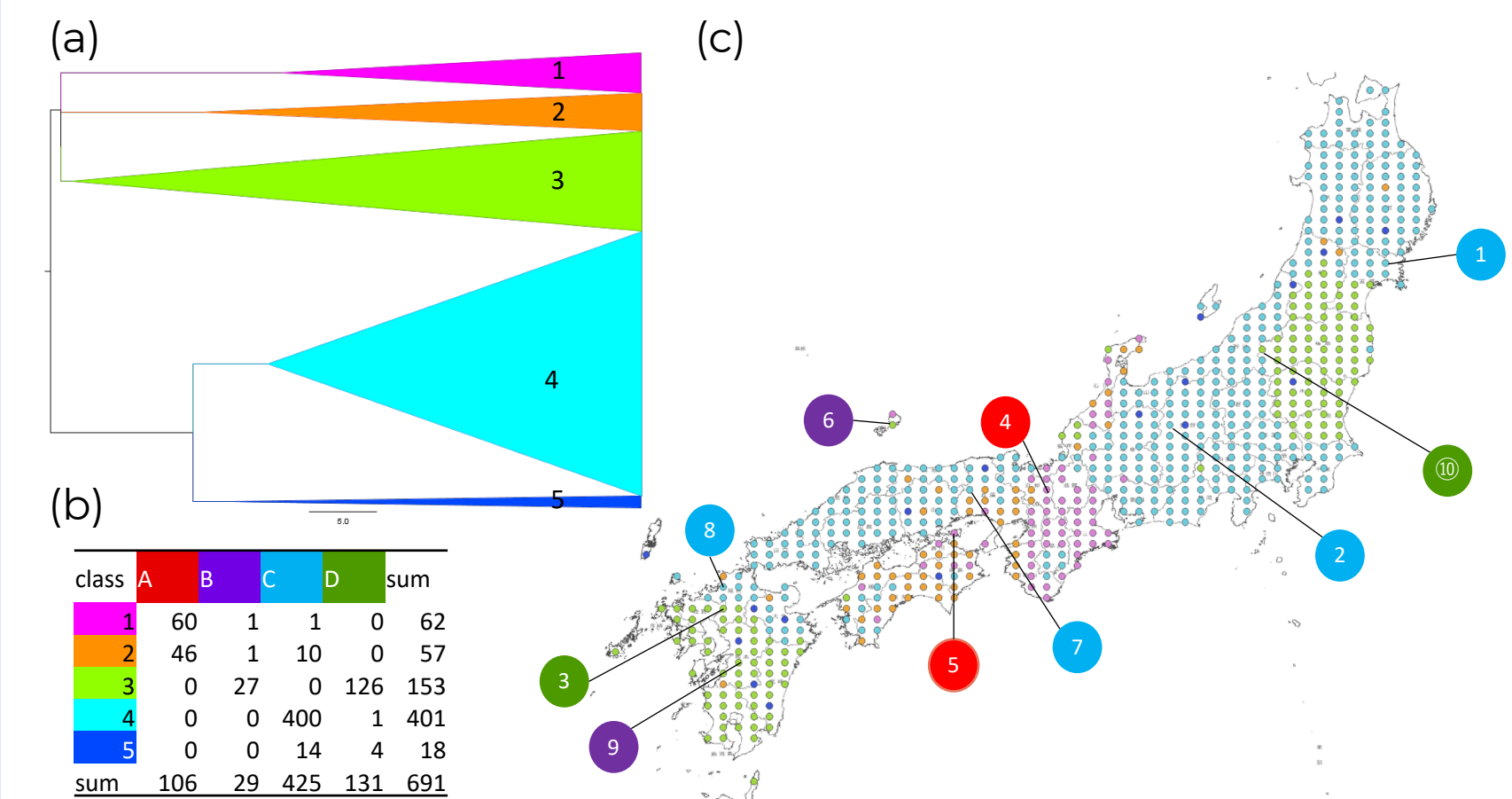


Figure 6 (a) The maximum Clade Credibility tree (691 points) and five classes of accent patterns, (b) the relationship between the classes and accent types A-D (see Fig. 1), and (c) the geographical distribution of the classes.

- The posterior distribution of mutation rates indicates that
 - tones are more likely to be lost than pitch changes.
 - especially in accents with tones and no pitch changes, where the rate of tone loss is extremely high (Figure 3).
- There was a moderate degree of agreement between the MCC tree results and the cladogram constructed by Phonological methods (Figure 4, 5). Only number 7 is different.
- Class **C** (pitch change only type) is classified into 2, 4, and 5 (Figure 6). It may show that C-type accents have occurred separately (i.e. convergent evolution).

Discussion

- By assuming a higher loss rate for tone than for pitch change
 - we can explain the observed distribution of accent patterns,
 - in which the most complex accent pattern is found around Kyoto, the ancient capital.
 - and those lacking tone in the periphery.

Future studies would incorporate more characteristics of accents to elucidate the detailed process whereby the variety of dialectic accents have descended from their common ancestor.

Acknowledgment

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