

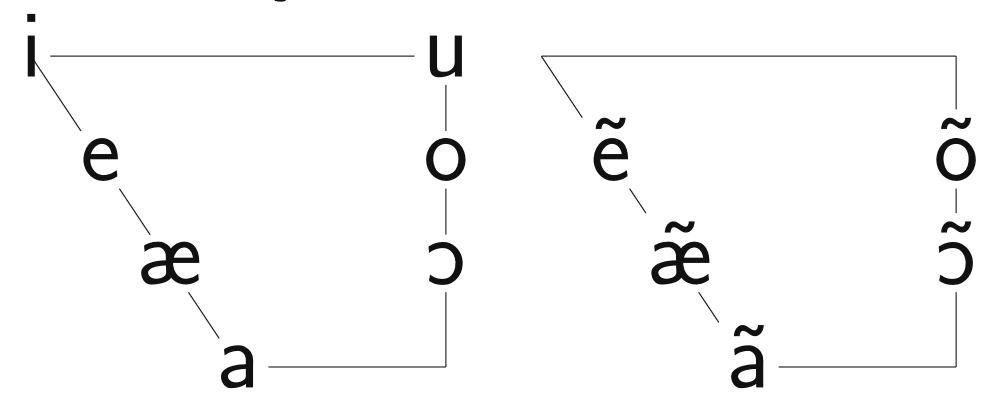
Modeling the nasal vowel inventories predicted by phonetic biases and learning

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Nasal vowels: typological asymmetry

Across languages, nasal contrasts are more common for **low** vowels than high vowels e.g. Amuzgo (Longacre 1966):

Oral inventory vs. nasal inventory



Possible cause?: Bias in production

Low vowels produced with larger velar opening

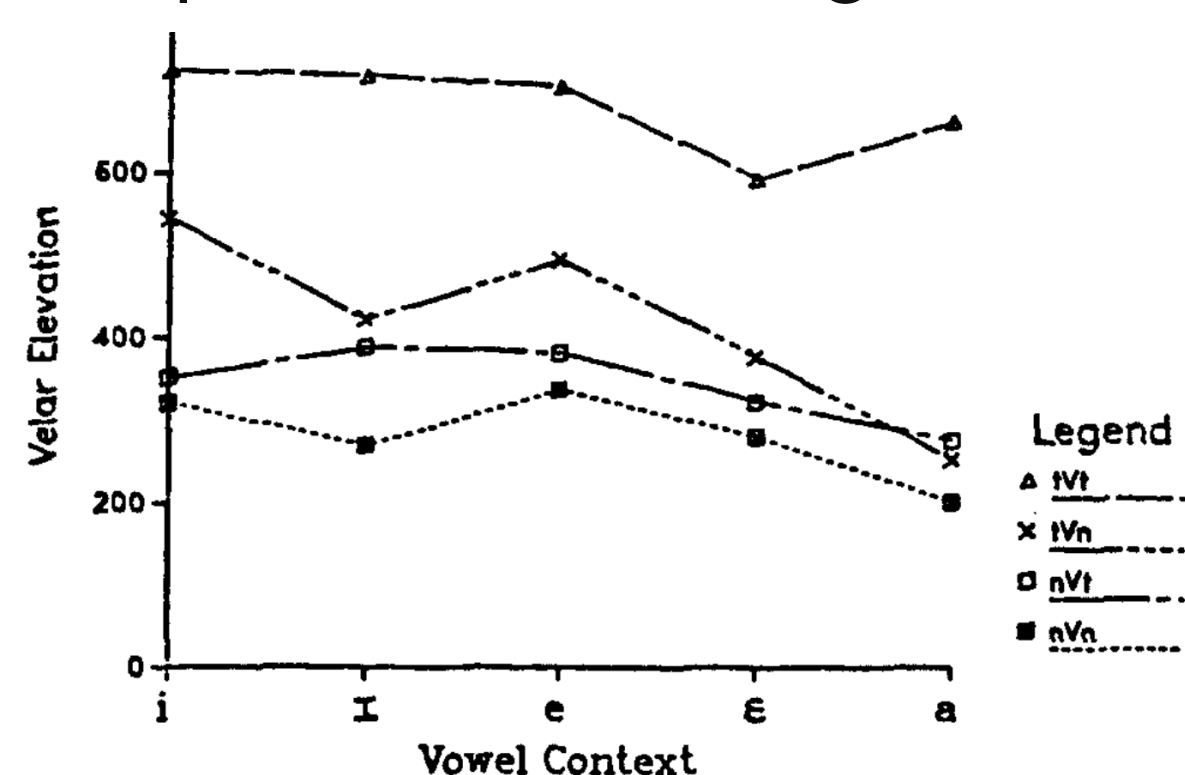
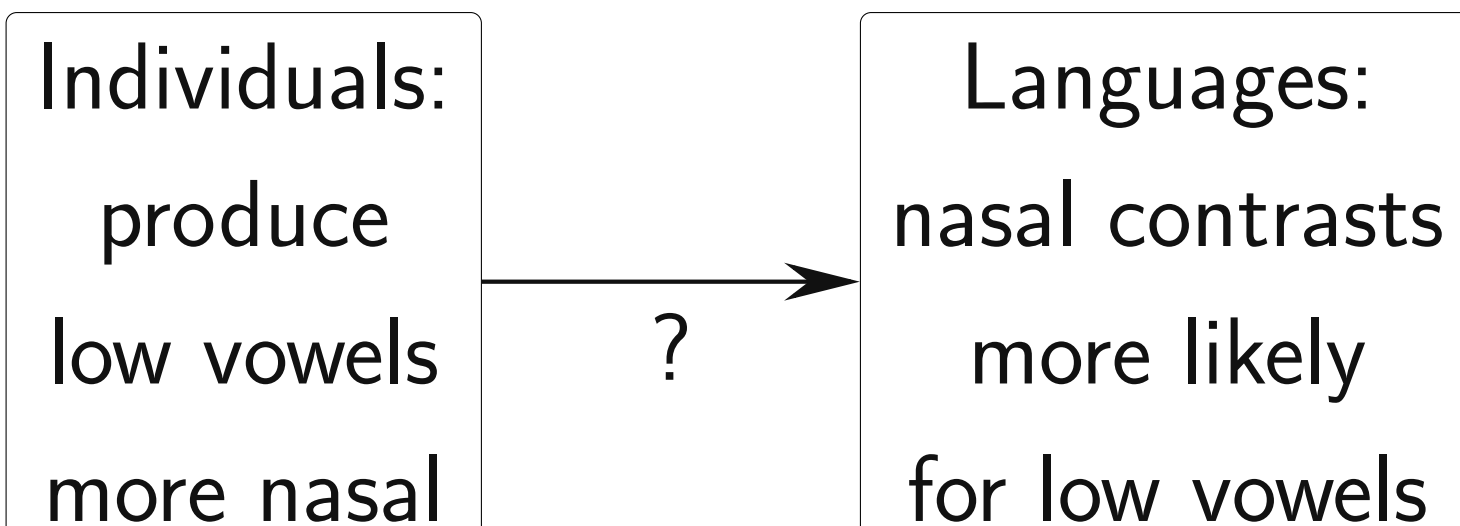


Figure: Relation between vowel height and velar elevation for Hindi oral vowels. Adapted from Figure 7 of Henderson (1984).

- ▶ More velar opening → more coupling with nasal cavity → more nasal
- ▶ Proposed as possible cause of the typological asymmetry: Henderson (1984), Whalen & Beddor (1989), Blevins & Garrett (1993), Hajek & Maeda (2002), Barnes (2002)

Linking hypotheses for phonetic biases?



Specifying a possible mechanism:

- ▶ How do speakers influence sound change and contrast?

Mixture of Gaussians (MOG) Learner

- ▶ Common learning and sound change model (e.g. Kirby (2013), Gubian et al. (2023))
- ▶ Search for set of categories that maximize likelihood of input data (e.g. vowel tokens)
- ▶ **Less overlap, more likely to be learned as separate categories.**

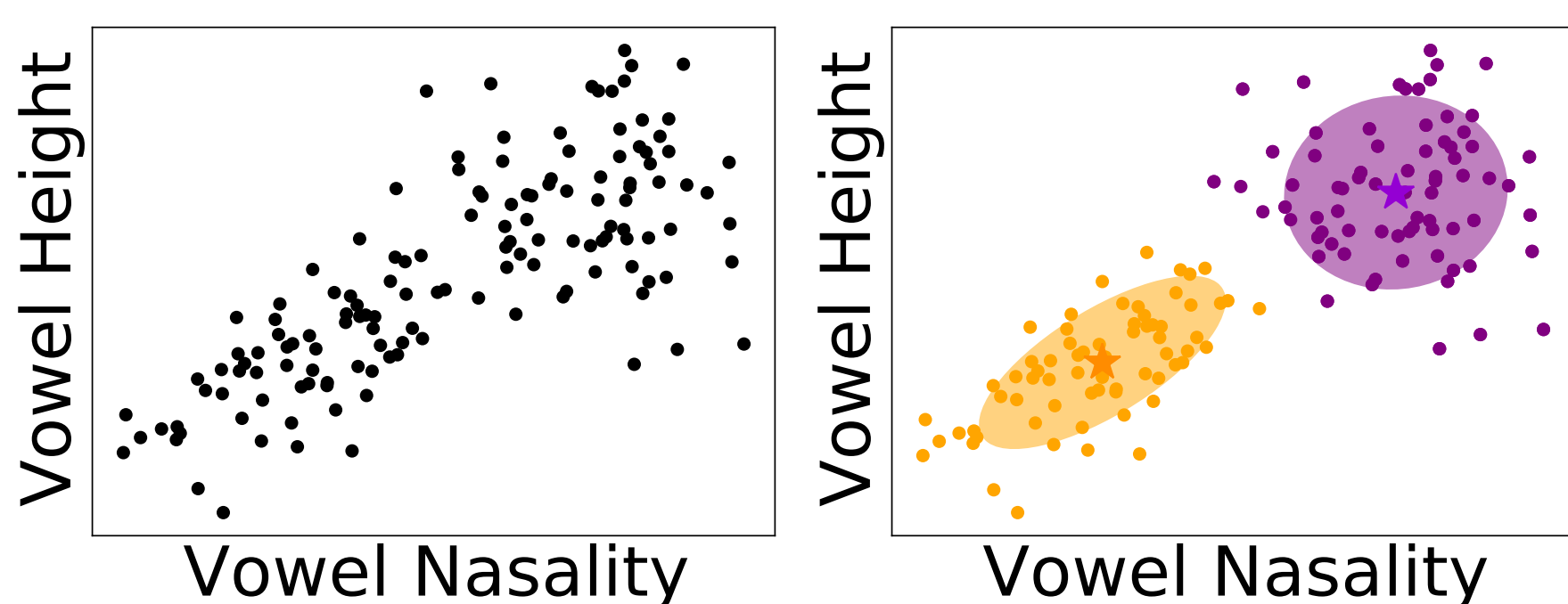


Figure: Example MOG input and output

Learning and sound change

Child input: noisy samples from parent → child can learn different categories

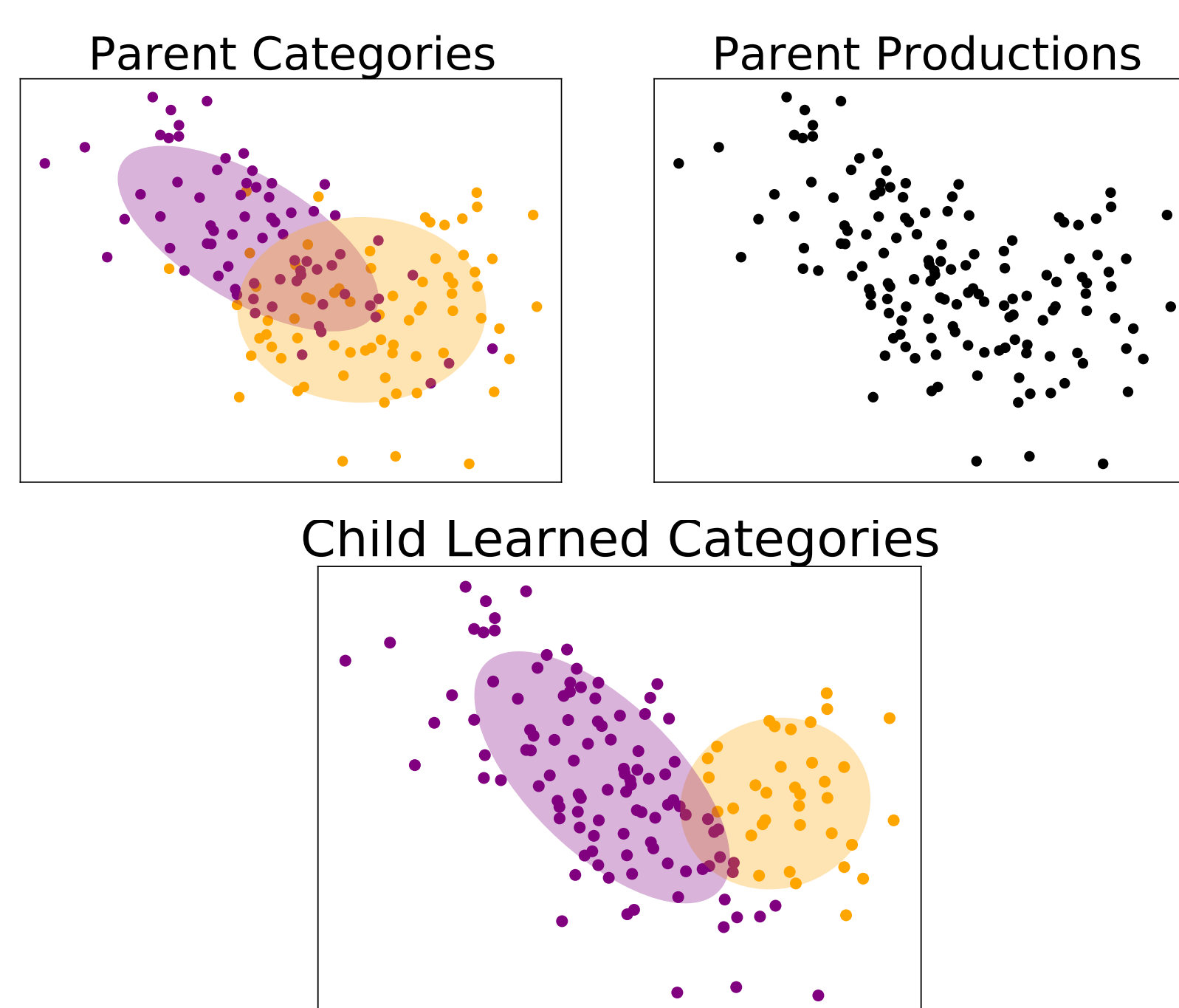
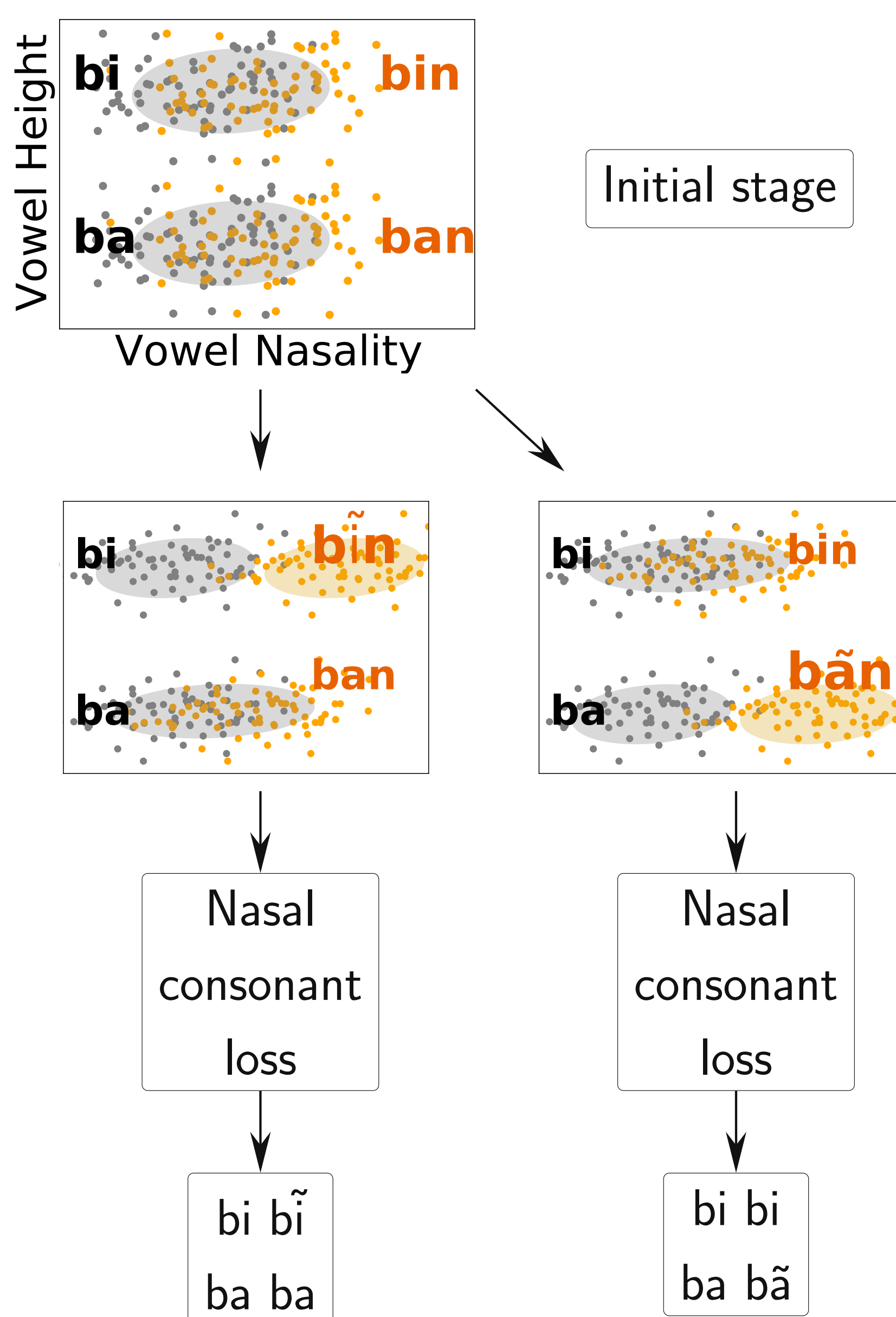


Figure: Example category change

Pathways to nasal vowel inventories

- ▶ Assume starting point with no nasal contrasts, with 4 toy lexical items (bi, bin, ba, ban)
- ▶ Assume nasal contrasts start with nasal allophony before nasal consonant (e.g. bi vs bĩ)
- ▶ Assume nasal allophony is represented as split into nasal/oral categories.



- ▶ Want a model to predict the low vowel pathway (right) as more likely than the high vowel pathway (left).
- ▶ **Does adding the production bias make this prediction?**

Implementing the low vowel production bias hypothesis

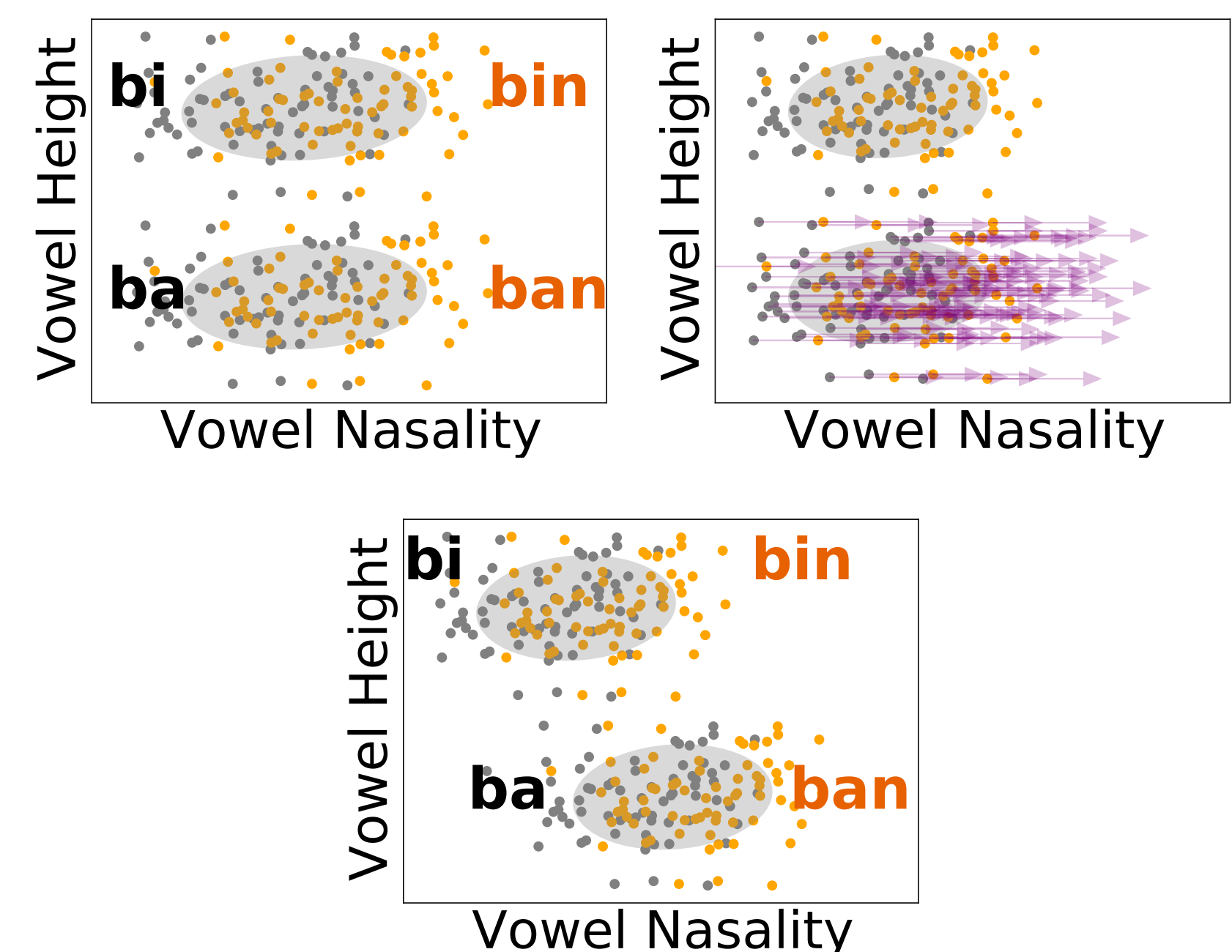


Figure: Speakers' intended low vowels (top left); production bias shift (top right); resulting shifted vowel distributions (bottom).

- ▶ Speakers' intended low vowels uniformly shifted toward greater nasality, qualitatively reflecting Henderson (1984)'s measurements of production bias.
- ▶ **Amount of overlap between oral-context and nasal-context versions of low vowel (ba vs ban) is still the same as for high vowel (bi vs bin).**
- ▶ Oral/nasal low vowels no more likely to be learned as separate categories; low vowel pathway no more likely
- ▶ Challenges the hypothesis connecting the typological frequency of low vowels' nasal contrasts

Empirical questions raised by modeling

- ▶ Greater difference in nasality between contexts (ba vs ban) for low vowels?
- ▶ Revised learning model, jointly inferring category and context? (cf. Ohala 1994; Beddor 2009)?
- ▶ Other phonetic parallels with nasal vowel typologies? (e.g. Whalen & Beddor (1989); Hajek & Maeda 2000)

Conclusion

- ▶ MOG does not predict a causal relationship between the nasal production bias and typology.
- ▶ Raises concrete questions about vowel phonetics and category learning.
- ▶ Hypothesized relationships between phonetics and typology depend on assumptions about learning.