Coronal underspecification as a possible result of transmission noise

Coronals seem to be special: they are cross-linguistically more frequent (Maddieson 1984), are acquired earlier (Stemberger & Stoel-Gammon 1991), convey less information (Hume, Hall & Wedel 2016), and assimilate more frequently than labials or dorsals (Boersma 1998). This special status led several phonologists to propose that coronals are featurally underspecified (e.g., Lahiri & Reetz 2002; Dresher 2009). We present evidence from a learning experiment supporting the underspecification of coronals, and a neural network simulating the experimental results. In this neural network, we incorporated transmission noise.

We conducted a learning experiment with German listeners. Participants ($n = 12$) were exposed to a set of syllables, either /pa/, /ta/ and /ka/, or /ba/, /da/ and /ga/; these syllables were presented in isolation, and all of them occurred 24 times in random order. Participants were asked to estimate how often they had heard the sounds. The frequencies of /ta/ and /da/ were systematically underestimated: the coronals received statistically significantly lower estimates than the other places of articulation (coronal vs. labial: $p = .009$; coronal vs. velar: $p = .007$; labial vs. velar: $p = .835$). We interpret this underestimation as evidence for the underspecification of coronals: the repeated activation of the [labial] and [dorsal] feature values may lead to higher frequency estimates, and because no feature specification exists for the coronals, their estimate falls short.

We then created a neural network simulating the acquisition of the feature combinations that appeared in the experiment. The network learns combinations of a place feature ([labial], [coronal], [dorsal]) and a voicing feature ([–voice], [+voice]), where both features correspond with phonetic continua. Additionally, we implemented the observation that in real-life learning, language transfer between the teacher and the learner is imperfect because transmission noise may scatter input tokens in the phonetic space (Ohala 1981): it may, for instance, cause an intended labial sound to be perceived as mostly labial and also slightly coronal. Now, coronal place has an advantage over the other two places of articulation: the transmission noise scatters some tokens from both adjacent categories into coronal place, while only intended coronal tokens are scattered into the adjacent places (see Fig. 1). In our network, this entails that adjacent groups of place nodes may be activated simultaneously. We ran 2,000 neural networks, each of which learnt 10,000 input tokens, with identical probabilities of occurrence for intended labials, coronals and dorsals. Due to the noise-induced scattering, the resulting cumulative activation of the coronal nodes was significantly higher than that of the labial and dorsal nodes (both $p < .001$). There was no such difference between the labials and dorsals ($p = .209$). Additionally, this higher activation leads to a higher output frequency for the coronals than for labials or dorsals (both $p < .001$, lab. vs. dor. $p = .923$), even if all places of articulation have equal input probabilities.

We propose that the occurrence of transmission noise plays a role in underspecification at the phonological level, for two reasons. (1) A relation may emerge between intended coronals and any place feature value, and the coronal place nodes may be activated for any intended category, so there are more mismatches between intended and perceived categories in the coronals; (2) as a result of the transmission noise, coronals are more frequent than labials and dorsals.

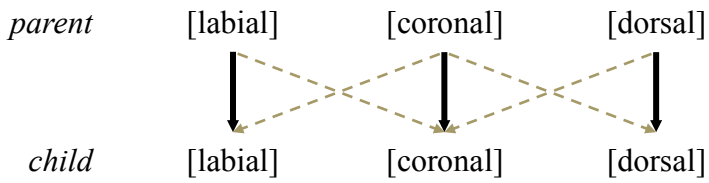

Fig. 1. *Schematic representation of the relations between intended and perceived categories: there are more mismatches for coronals (namely 3) than for labials (2) or dorsals (2).*

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