

## Probabilistic Enhancement and Australian English /æ/

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Kirby's (2013) Probabilistic Enhancement Hypothesis (PEH) proposes that enhancement (emphasis of phonetic features to increase contrast precision) is an adaptive strategy to ensure perceptibility of phonemic contrasts. PEH hinges on three key concepts: *bias* (phonetic asymmetries [see Garrett & Johnson 2013] which may reduce the integrity of a contrast), *precision* (the accuracy with which a contrast can be perceived), and *redundancy* (the range of variously weighted phonetic cues specific to the contrast). The raising of [æ̃] which is a sound change in progress in Australian English (AusE) allows us to test the predictions of PEH. Our hypotheses are as follows:

- Phonetic *bias* will give rise to synchronic variation because the addition of nasal resonance has been shown to affect the (perceived) phonetic height of [æ̃].
- [æ̃] raising may lead to potential reduction of *precision* between [æ̃] and [ẽ], e.g. *pan* vs. *pen*.
- *Redundant* features (e.g. duration) may be selectively deployed to maintain contrast.
- Crucially, a relationship will be established between the *extent* of precision loss and the *degree* of redundant feature enhancement.

30 female AusE speakers (18-30 years) read /CVn/ and /CVd/ words (where C was /b, d/ and V was /æ, e/) in isolated and sentence contexts five times in random order. Sentences included the forced contrast construction: 'They don't say X, they say Y'. Where X and Y were either /CVn/ or /CVd/ words (e.g. 'They don't say BEN, they say BAN'). Each word was elicited in both X and Y positions. Duration, F1 and F2 were extracted for /æ/ and /e/ from the 2<sup>nd</sup> to 4<sup>th</sup> repetitions using standard techniques. Multilevel modelling (with speaker as random factor) was used in the analyses. Analysis 1: F1, F2 and duration in isolated words were separately analysed to compare the factors nasality and vowel type. [æ̃] was significantly higher, fronter and longer than [æ] (p<.0001) and there was extreme variation in F1 and F2 of [æ̃] indicating predicted *synchronic variability*. To make sense of this variability, we used kmeans clustering based on the difference between F1 of [æ̃] and [æ] to identify speaker groups: 7 speakers were extreme nasal raisers, 16 were moderate raisers and 7 were non-raisers. Extreme [æ̃] raising could potentially reduce *contrast precision* with [ẽ].

Analysis 2: F1, F2 and duration were separately analysed to compare [æ̃] and [ẽ] in the extreme raiser group. No difference was found for F1, supporting loss of contrast precision. However, contrast was preserved by duration (p<.0001) (i.e. *redundant feature*). To determine if this effect could be considered enhancement, we examined the relationship between F1 and duration.

Analysis 3: Significant negative correlations between F1 and duration of [æ̃] in the isolated word context were found for the combined raiser and non-raiser group (*ban*: r(40)= -.395, p<.01, *dan*: r(40)= -.379, p<.013). The higher the nasalised allophone the longer it is, suggesting contrast enhancement. Duration appears to be reassigned as the primary cue to resolve potential conflict.

Analysis 4: To further test the hypothesis that increased duration for raised [æ̃] is an enhancement strategy, we compared the forced contrast sentence data for the two groups. Our prediction that reduced spectral contrast (i.e. raisers) would lead to increased duration was supported. Compared to the non-raiser group, the raisers had significantly longer [æ̃] (*ban*: p<.003, *dan*: p<.0001) and crucially showed a greater length *difference* between [ẽ] and [æ̃] (*ban*: p<.025, *dan*: p<.001).

Taken together, these results support PEH by showing that redundant cues (i.e. duration) can be redeployed and enhanced according to the degree to which contrast precision is compromised.

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