Neurophysiological evidence for phonological primitives

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Background. A long-standing issue in phonological theory is what the primitives of phonological representations are. Some have posited that the primitives are Distinctive Features (Clements, 1985), some that they are Elements (Backley, 2011). The various sets of primitives differ with respect to their grounding, valency, and combinatorics. While the relationship between the phonological entities in a representation and the phonetic realisation of an utterance is not necessarily transparent, phonological structure is reflected in the way people process the speech sounds of their native language. The current study is designed to map the way a listener's native phonological system influences speech perception, in order to evaluate predictions that arise from the structure of Feature-based versus Element-based representations.

Current study. Synthesised tokens of the French vowels /y/, /u/, /o/ and /ø/ (see fig. 1) are presented in a sequence where one vowel is repeated very often, occasionally interrupted by the other vowels, while the listener's electroencephalogram (EEG) is recorded. Interruption of a regular auditory pattern evokes an automatic brain response known as the Mismatch Negativity (MMN; Näätänen 2001), which serves as an index of perceived contrastivity between the repeating and the interrupting vowels. Contrasts in place, height, and both simultaneously are investigated. The data are currently being collected.

Analysis. The first issue to be established is whether changes in the same stimulus dimension – be it in terms of formants, Features or Elements – induce the same kind of MMN response. In all frameworks, parallel lines in fig. 2 are expected to induce similar effects. Related is the issue of additivity, where frameworks employing abstract representations diverge from representations in terms of acoustic distance. If each dimension contributes an independent primitive to the representation, the brain is expected to parse a sound into these primitives and assess differences on each dimension independently. This entails that responses to multidimensional contrasts (diagonals in fig. 2) are expected to be similar to the addition of two unidimensional contrasts (horizontal and vertical lines in fig. 2). Finding such additivity of MMN responses supports theories in which phonological representations consist of granular building blocks like Features or Elements over representations purely in terms of continuous acoustic properties. If no additivity is found, this indicates that vowel place and height are processed in an integrated manner rather than independently.

The second issue in the analysis is directionality. If all vowel properties are represented with equal weight, then MMN magnitude must be similar for each direction of a contrast. This is the expected result if representations are fully specified feature matrices. However, if all properties are not represented equally, as is the case in the Featurally Underspecified Lexicon (FUL; Lahiri & Reetz 2002) model but also in Element Theory (ET; Backley, 2011), one direction of contrast is expected to be stronger than the other. According to FUL, changes from richer to less specified stimuli give the strongest mismatch and thus a stronger response compared to the mere 'no mismatch' in the other direction. Element-based representations predict the exact opposite asymmetries based on their representational content.

Implications. The current study maps the way the neural system parses speech stimuli into phonologically relevant properties. If this occurs in an independent, additive manner,

which can be concluded from responses to multidimensional and unidimensional contrasts, this supports the idea that vowel place and height are represented with granular primitives such as Features or Elements. Concluding which type of phonological primitive listeners uncover in a speech sound can be done based on a directionality analysis. Symmetric responses indicate fully specified representations whereas asymmetric responses indicate featurally underspecified or melodically specified representations. The specific direction of the asymmetry shows which of these two types of primitives best accounts for the data.

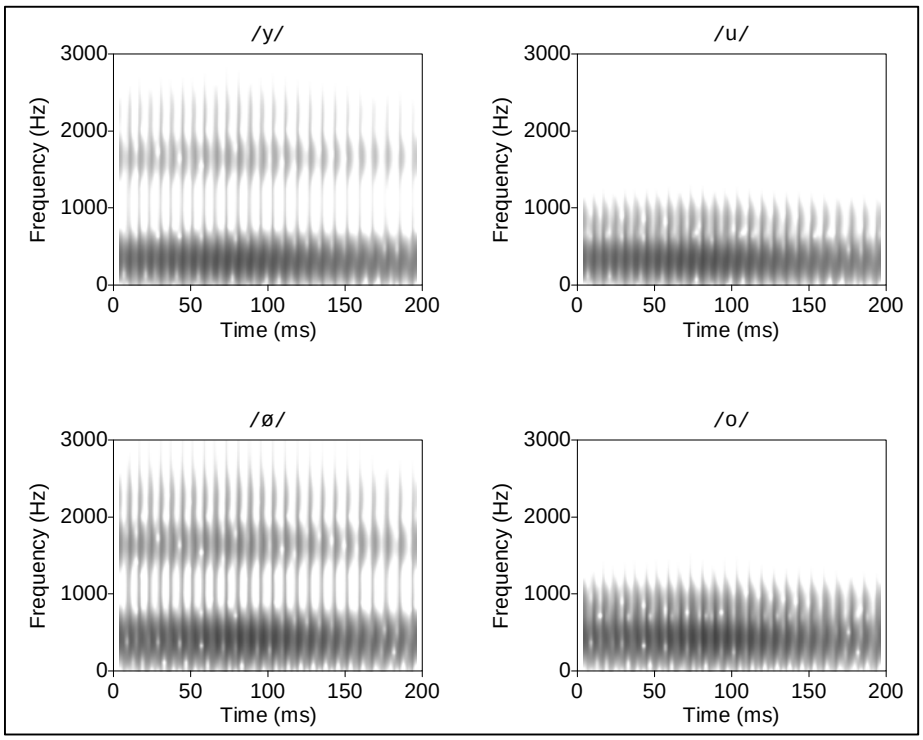

Figure 1: Spectrograms showing the lower formants of the four French vowels. Note the F1 difference for vertical pairs and the F2 difference for horizontal pairs.

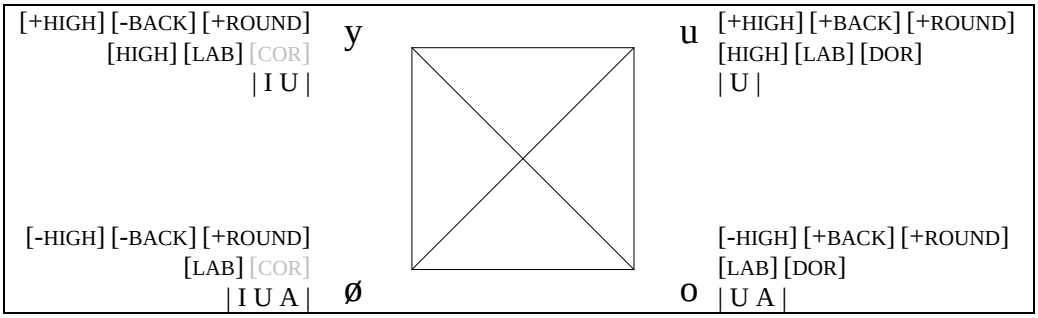

Figure 2: Vowel contrasts and specifications assuming full specifications, featurally underspecified specifications, and melodic (Element-based) specifications.

References

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