EEG-based evidence supporting the truly phonological character of velar softening

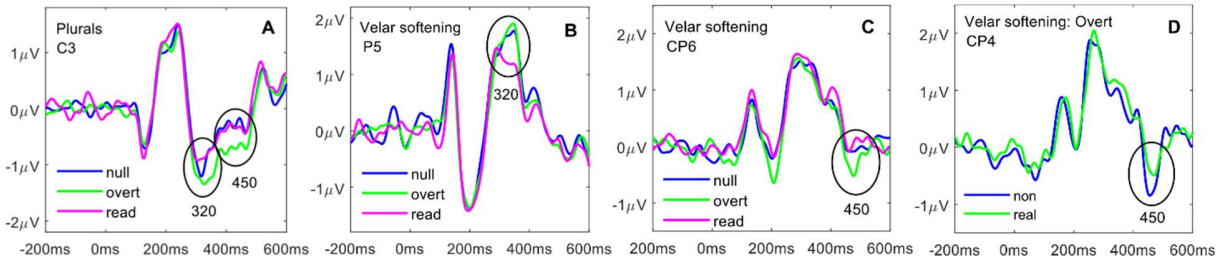
Background. For the past 50 years or so (starting with Kiparsky 1968-73), a central question for linguistic theory is whether the pieces (morphemes) that may be identified by the analyst are really the ones that are stored in long term memory and manipulated by the cognitive system of present day native speakers. Given *electric - electricity*, for example, are we facing suppletion (two independent lexical items /*electric*/ and /*electricity*/), allomorphy (three lexical items /*electric*/, /*electris*/, /*-ity*/, the s-allomorph being chosen in the presence of /*-ity*/) or morpho-phonology (two lexical items /*electric*/, /*-ity*/, their concatenation provoking *k→s*)? In production, suppletion requires lexical access but no concatenative or phonological computation. Allomorphy on the other hand engages lexical access and concatenation, but no phonological activity. Finally, morpho-phonology mobilises all three actions.

For decades, phonologists have tried to establish criteria ('evaluation metrics') that are able to decide for any given alternation whether it is lexical, allomorphic, or morpho-phonological in nature. Despite the effort, all attempts remain inconclusive (Bermúdez-Otero & McMahon 2006: 383ff). This means theories differ in the scope of phenomena they consider part of phonology, while theories can only be meaningfully compared if the set of things to be explained is the same. Our study aims to bring new evidence to the table in the discussion regarding the nature of alternations, particularly velar softening in English.

Experimental paradigm. Sahin et al. (2009) presented evidence from patients with intra-cranial electrodes showing that lexical access, morpho-syntactic processing, and phonological processing can in principle be separated in time and space based on characteristic electrophysiological responses at 200 ms, 320 ms, and 450 ms respectively. These findings were elicited in a silent pronunciation paradigm with three experimental conditions: *Read*, *Null*, and *Overt*. Participants were presented visually with a cue indicating the condition followed by a word, and were instructed to pronounce the word silently in their head according to the preceding cue. In the current study, we aimed 1) to replicate these findings in surface EEG with healthy adults producing English plurals to confirm the sensitivity of the paradigm, and 2) to apply the paradigm to investigate the processes involved in English velar softening. For the replication with plurals, 80 words matched on frequency and phonological properties were used. For *Read*, only the repetition of the word is required, eliciting lexical access but no further processing: *Repeat: + rock = rock*. For *Null*, the cue requires appropriately inflecting the word, but the result is a null (i.e. unpronounced) inflection: *This is the _ + rock = rock*, eliciting lexical access and morpho-syntactic processing but no phonological computation. For *Overt*, the cue induces overt (i.e. pronounced) inflection of the word (*Those are the _ + rock = rocks*), requiring all stages of processing including progressive voice assimilation at the phonological processing stage. To elicit velar softening, 43 real words (*electric, critic*) and 37 nonwords (*nectic, glyphic*) were used with the cues *Repeat:* for *Read*, *This is really _* for *Null*, and the cues *They talk about _* (eliciting *electricity*, *necticity*) or *You need to _* (eliciting *criticise*, *glyphicise*) for *Overt*.

Results. The EEG from 13 participants (20 planned) was recorded from 64 scalp electrodes during silent pronunciation tasks involving either pluralisation (i.e. voice assimilation) or velar softening in the *Overt* conditions. All participants were monolingually raised right-handed native speakers of Standard Southern British English without neurological or language impairment. Raw data were filtered, corrected for eye movements, and analysed in epochs that were time-locked to

the onset of the stimulus word. In the pluralisation task, the response at 320 ms had a different distribution than the response at 450 ms (as in Sahin et al. 2009), overlapping at electrode C3. Panel A shows the ERP for the *Null* and *Overt* conditions patterning together at 320 ms, while at 450 ms the *Overt* ERP diverges from the rest, mirroring Sahin et al. (2009). In the velar softening task, with different stimuli and different presumed morpho-phonological processes than the pluralisation task, the distributions of the responses at 320 ms (panel B) and 450 ms (panel C) do not overlap, but again show the same basic pattern: divergence of *Read* at 320 ms, divergence of *Overt* at 450. Crucially, nonwords elicit stronger responses in the *Overt* condition at 450 ms (panel D) compared to real words.



Discussion. These results show that the basic paradigm developed by Sahin et al. (2009) carries over to surface EEG in healthy adults, and is differentially sensitive to morpho-syntactic concatenation (at 320 ms) and phonological processing (at 450 ms). Moreover, this sensitivity is not restricted to inflectional processes, but extends to a derivational process like velar softening. This means our results can give evidence to the nature of the process of velar softening: whether it is the result of suppletion, allomorphy, or online computation. For nonwords, the derivation necessarily involves online computation, since suppletion and allomorphy rely on the root being present in the lexicon, while these options are available to real words. The average ERP indexing phonological processing in the *Overt* condition is larger for nonwords than the average ERP for real words. Our interpretation of this fact is that speakers have no other choice than to use online phonological computation when confronted with nonwords, supporting the idea that velar softening is part of their phonological competence; whether analogy could provide an alternative explanation will be discussed in the talk. On the other hand, at least some real words may not always undergo phonological processing but rely on suppletion or allomorphy instead, resulting in less activity at 450 ms. There is substantial experimental evidence to the end that the more frequent a morphologically complex word, the higher chance it stands to be lexicalized as one single chunk (Caramazza et al. 1998, Schreuder & Baayen 1995).

The contribution of our study to phonological theory is its support for the presence of velar softening in the phonological competence of speakers, documented for both real and nonwords.

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