Comparing incomparable frameworks — A model theoretic approach to phonology

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Phonology as a field features a dazzling diversity of linguistic frameworks, which differ vastly in their views of language, their theoretical primitives, and their concrete implementations. While plurality of approaches is a good thing in general, a non-uniform style of exposition makes it difficult to tell superficial and fundamental differences apart. Following in the footsteps of Potts and Pullum (2002), we show how ideas originating from the field of model theoretic syntax (Rogers 1996, 1998) can be used to abstract away from merely syntactic differences so that proposals can be directly compared based on the set of structures they license. This also allows us to elucidate the cognitive claims those theories encompass and compare them with respect to learnability and processing requirements.

To illustrate the flexibility of the approach, we match Government Phonology (GP) (Kaye et al. 1985, 1990), which is a representational autosegmental framework, against the prototype of a derivational theory of phonology, classical SPE (Chomsky and Halle 1968). We develop a formal implementation of GP in a restricted modal logic over string-structures with the phonological features as our propositional variables and two diamond operators $\lhd$ and $\rhd$ to move us from one segment of the string to the immediately preceding or following one. The simple formula $O \rightarrow \rhd N$, for example, requires every onset to be followed by a nucleus.

We then show how the power of GP increases by the addition of operators familiar from temporal logic such as UNTIL and NOW. After a short discussion of the connection between modal operators and restrictions on autosegmental spreading, we map the different variants of GP to levels of the subregular hierarchy (cf. Pullum and Rogers 2006) and well-known classes of semigroup theory (cf. Pin 1997). Using the formalization of SPE as given in Kaplan and Kay (1994), we then prove that renditions of GP with fixed point operators (Vardi 1988) license a structure iff it is licensed in SPE.

With our formal hierarchy of phonology in place, we look for empirical phenomena that could motivate the transition from one class to the next more powerful one. To that end, we isolate two long-distance processes. The first one is n-retroflexion in Sanskrit, also known as *nati* (see Schein and Steriade 1986 and Hansson 2001), which under rather peculiar conditions turns the first n following a continuant retroflex consonant into a ɳ. In GP, harmony is analyzed as spreading of the relevant feature from the trigger to the target. This spreading can take place locally, moving the feature in small steps from segment to segment until the target is reached, or in an unbounded one fell swoop operation, which is only available in more powerful implementations. We prove that the only way to account for *nati* with local spreading is the use of inessential features (Kracht 1997), i.e. empirically unattested features that have no linguistic correlate and only serve the purpose of encoding non-local information in a strictly local way. From results of Thatcher and Wright (1968) and Doner (1970) we infer that inessential features increase the generative capacity of a theory, such that there is an equivalent GP implementation that uses more powerful logical operators but no inessential features. The expressively weaker class of GP variants with local spreading and no inessential features thus is empirically inadequate.

Using a similar argument, we show that without inessential features, the kind of stress assignment encountered in languages like Creek and Cairene Arabic requires the full power of SPE or GP with fixed point operators. In both languages, stress is assigned to the ultimate or the penultimate syllable depending on whether the number of syllables in the word is odd or even (ignoring some special cases; see Mitchell 1960, Haas 1977 and Hayes 1995). Crucially, there is no overt exponent of secondary stress assignment that could be used to convert this unbounded dependency into a sequence of iterative local dependencies, forcing any strictly local account to invoke inessential features. Stress assignment thus involves counting *mod* 2, which is known to lie beyond the capabilities of star-free grammars, which in turn are expressively equivalent to linear temporal logic. The next more powerful class of grammars are the regular grammars, which can even count *mod n* and correspond to SPE (see above).

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