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Phonological typology in Optimality Theory and Formal Language Theory: Goals and future directions

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Abstract. Much recent work has studied phonological typology in terms of formal language theory (e.g. the Chomsky hierarchy). This paper considers whether Optimality Theory grammars might be constrained to generate only regular languages, and also whether the tools of formal language theory might be used for constructing phonological theories similar to those within Optimality Theory. It offers reasons to be optimistic about the first possibility, and skeptical about the second.

Where do phonological patterns reside in the Chomsky hierarchy of formal languages? This is the guiding question in the approach to phonological typology developed in Heinz (2007) and much subsequent recent work, including Jardine (2016; 2019), the inspiration for the present remarks. Optimality Theory (OT; Prince and Smolensky 1993) also aims to situate phonological patterns in a formal space, but does so with goals that were at least originally quite different from those of the Formal Language Theory (FLT) approach. One might well ask whether OT can be formulated so as to meet goals similar to those of FLT, as well as whether FLT can be formulated so as to meet goals similar to those of OT. Jardine (2019) expresses skepticism about the first of these possibilities and optimism about the second. In what follows, I'll explain why my own outlook is the reverse.

The original goal of OT is that of its predecessor, the principles and parameters framework of Chomsky (1980), as developed in studies of phonological typology such as Hayes (1980; 1995) and Archangeli and Pulleyblank (1994). That is, to provide a formal framework that allows for the specification of grammatical systems that generate all and only the attested language types in some empirical domain, such as word level stress or vowel harmony. The central innovation of OT is its introduction of ranked, violable constraints. By formalizing the notion that satisfaction of one constraint can force the violation of another, OT allows the interaction of relatively general constraints to deal with the specificities of individual languages. Violability also leads to the ability of a relatively small constraint set to generate a relatively rich but still interestingly restrictive typology of possible languages. Most OT research provides examples of how violability can aid in the analysis of individual languages and in the study of typology; see Prince and Smolensky (1993; ch. 4) for a direct comparison of a violable constraint theory with a portion of Hayes' (1980; 1995) parametric stress theory, and Potts et al (2010; sec. 5.1) for a direct comparison of a violable constraint theory with a portion of Archangeli and Pulleyblank's (1994) parametric theory of vowel harmony.

Frank and Satta (1998) were amongst the first to address the question of the overall formal expressiveness of the OT framework within the Chomsky hierarchy (see also Eisner 1997). Johnson (1972) shows that the effects of the rewrite rule formalism of Chomsky and Halle (1968) can be simulated with a finite state transducer (FST). Frank and Satta (1998) show that there are patterns generated by OT that are not expressible by an FST, and discuss potential limitations on OT constraints that would make the system regular (i.e. able to be generated by an FST), in particular limiting constraints to finite numbers of violations. The restrictions have not been adopted in subsequent work, because imposing an upper bound on the number of violations of a constraint is not generally feasible without a stipulated upper bound on the length of representations. We can conclude, then, that standard OT is super-regular.

Might it be possible to formulate a version of OT that retains standard OT's ranking and violability, and its usefulness for formulating theories of empirical domains like stress and vowel harmony, but which is only regular in its overall expressiveness? Jardine (2019; sec. 3) expresses skepticism, citing examples of super-regular patterns that standard OT has been shown to generate. My own cautious optimism comes from the body of recent work starting with McCarthy (2000) demonstrating that some unattested patterns generated by the global parallel evaluation of standard OT are not expressible with the more local evaluation of Harmonic Serialism. As Lamont (2019) shows, adopting Harmonic Serialism is not a simple panacea for this kind of overgeneration. However, Lamont (2019) also shows that under some reasonable additional assumptions, the super-regular "majority rules" pattern that is his focus can be eliminated, as well as many if not all other super-regular patterns.

What about the possibility of doing phonological analysis and creating typological theories along the lines of OT but with FSTs and other formal tools of FLT? Though he does not put it in exactly these terms, Jardine (2019; sec. 4) expresses optimism about the related possibility of imposing substantive restrictions on the set of patterns generated by FLT: "…just as substantive statements can be made in OT by stipulating the content of CON, we can similarly make substantive statements in FLT phonotactic grammars through stipulations on what constraints are available to grammars." Much of my own skepticism about the prospects for this endeavour comes from the observation in the preceding sentence: "The only difference is that the constraints in these FLT characterizations are interpreted as inviolable." As noted above, violability is key to OT's success as a framework for phonological theory. More generally, it seems to me unlikely that future FLT-based formalisms will give phonologists the means to transparently express the regularities that hold of phonological systems, in ways comparable with existing rule- or constraint-based formalisms.

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