Learning Phonological Mappings by Learning Strictly Local Functions*

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1 Introduction

The current study identifies *locality* as a near-universal property of phonological input-output mappings that describe processes with local triggers and presents a learning algorithm which uses locality as an inductive principle to generalize such mappings from finite data. Input-output (or UR-SR) mappings like the one in (1) are integral to both the rewrite rules of Sound Pattern of English (Chomsky & Halle, 1968) and constraint-driven grammars like Optimality Theory (Prince & Smolensky, 1993, 2004).

(1) {(dip, dip), (baːd, baːt), (bom, bom), (deːg, deːk), ...}

In the above pairs, all word-final obstruents in the input are voiceless in the output. Phonologists will likely recognize this mapping as 'word-final obstruent devoicing', and within an SPE framework, it might be described with a rule like (2a). In OT, it can be captured in part by the constraint ranking in (2b).

(2) a. $[-\text{son}] \Rightarrow [-\text{voice}]/\_\_\#$
b. $*[-\text{son}, +\text{voice}]\# \gg \textsc{Ident}(\text{voice})$

Implicit in both formalisms is the fact that this mapping is *infinite*: for *any* input to which the rule or constraint applies, its output will have a word-final voiceless obstruent. The question of interest for the learning problem is how do children induce these infinite generalizations given only finite data?

We address this question by showing how the computational properties of the target mappings can aid in learning. It's been known since Johnson (1972), Koskenniemi (1983), and Kaplan & Kay (1994) that phonological rules describe regular relations, but regular relations are not believed to be identifiable in the limit from positive data (Gold, 1967). We instead propose that the phonological learner takes as its hypothesis space the class of Strictly Local functions, a subclass of the subsequential functions. Our interest in subsequential mappings stems from a body of work that has classified many phonological processes as subsequential (Gainor et al., 2012; Chandlee et al., 2012; Chandlee & Heinz, 2012; Heinz & Lai, 2013; Luo, 2013; Payne, 2013; Jardine, 2013). However, though Oncina et al. (1993) prove that subsequential functions are identifiable in the limit from positive data by the algorithm known as OSTIA, Gildea & Jurafsky (1996) found that OSTIA fails to learn phonological rules from natural language corpora. The current study builds on this work by modifying OSTIA so that it targets the Strictly Local subclass of subsequential functions. The resulting algorithm successfully learns a wide range of local phonological processes while also excluding other subsequential but non-phonological mappings.

This paper is structured as follows. Strictly Local functions and the formal languages on which they are based are discussed in §2. The algorithm OSTIA is presented in §3. The Strictly Local Function Learning Algorithm, an augmentation of OSTIA based on the properties of Strictly Local functions, is introduced in §4, along with the theoretical results and several simulations. §5 further discusses the issues that arise when using natural language corpora, and §6 concludes.

* Thanks to Jeffrey Heinz, Rémi Eyraud, James Rogers, and the audience at Phonology 2013 for valuable feedback and guidance.

Proceedings of *Phonology 2013*
Completed February 15, 2014