**Conditional blocking in Tutrugbu requires non-determinism: implications for the subregular hypothesis**

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Early work in computational phonology (Johnson 1972; Kaplan & Kay 1994) demonstrates that the types of rules used to define phonological transformations belong to the class of *regular languages* in the Chomsky Hierarchy. More recent work (Heinz 2010, 2017; Heinz & Lai 2013; Lai 2015; Chandlee 2014; Jardine 2016, a.o.) has contended that attested phonological transformations belong to some computationally less complex class, somewhere in the *subregular hierarchy*. Heinz & Lai (2013), for example, argue that attested vowel harmony patterns are *weakly deterministic* while unattested, "pathological" patterns are more complex than this, if not non-regular. Contra Heinz & Lai (2013), we demonstrate that the ATR harmony pattern of Tutrugbu (McCollum & Essegbey 2017) is not weakly deterministic. We argue that there is no hard boundary between subregular and regular phonology, but that subregularity exists as a computational simplicity bias, in line with previous work on learning biases in phonology (e.g. Moreton & Pater 2012).

ATR harmony in Tutrugbu proceeds leftward from roots to prefixes (1a-d). Comparing (1e,f) with (1g,h), however, we see that non-high vowels block harmony if a high vowel is in the word-initial syllable.

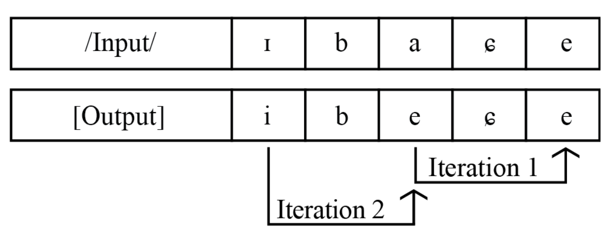
| | | | | | |
|---|---|---|---|---|---|
| (1) a. i-tí-ɕē | '1S-NEG-grow' | e. e-tí-ɕē | '3S-NEG-grow' | |
| b. ki-zi-wu | 'CM.5-REP-climb' | f. ke-zi-wu | 'CM.7-REP-climb' | |
| c. e-be-ɕē | '3S-FUT-grow' | g. ɪ-ba-ɕē | '1S-FUT-grow' | (*i-be-ɕē) |
| d. ke-be-wu | 'CM.7-VENT-climb' | h. kɪ-ba-wu | 'CM.5-VENT-climb' | (*ki-be-wu) |

Non-high vowels are thus *conditional blockers* in Tutrugbu. They block harmony only when a high prefix vowel in the word-initial syllable is also present; otherwise, they undergo harmony. The non-high blockers happen to be syllable-adjacent to the word-initial syllable containing the requisite high vowel in (1g,h), but the examples in (2) show that the initial high vowel and the blocker can be separated by arbitrarily many intervening syllables. The example in (2a) shows that three vowels may intervene between the blocking non-high vowel of the PROG suffix and the initial high vowel. The example in (2b) confirms that it is the height of the initial vowel that causes the distant non-high vowel to either block harmony (2a) or undergo it (2b). Finally, the example in (2c) illustrates that a high vowel intervening between a [+ATR] root and a blocking non-high vowel undergoes harmony, agreeing with the root vowel.

(2) a. kɪ-tí-ba-ba-á-wu 'CM.5-NEG-FUT-VENT-PROG-climb'
b. e-tí-be-be-é-wu '3S-NEG-FUT-VENT-PROG-climb'
c. bʊ-tí-ba-di-wu '1P-NEG-FUT-ITV-climb'

Chandlee (2014) argues that directional vowel harmony patterns are, computationally speaking, *strictly local*: the realization of a given vowel with respect to the harmonic feature depends on a locally-bounded context of length *k*, the maximum number of segments including the trigger, the target, and any segments in between. For a simple regressive ATR harmony language with CV-syllable structure, like Tutrugbu, the realization of a vowel's ATR feature value would be *right-subsequential* with *k*=3. As shown in (3), the output ATR value of each vowel in the mapping from input /ɪ-ba-ɕē/ to output [i-be-ɕē] depends on only the output ATR value of the following vowel, which is 2, *k*–1, segments away. But the example in (1g) demonstrates that this input-output mapping is ungrammatical in Tutrugbu. Regressive ATR harmony in this language thus cannot be right-subsequential.

(3)




Given that the realization of a non-high prefix vowel's ATR value depends on information both to the left and to the right of that vowel, it could be that the Tutrugbu pattern requires a composition of *right-* and *left-subsequential* mappings, as Heinz & Lai (2013) demonstrate to be necessary for bidirectional stem-controlled and dominant-recessive harmonies. The realization of the harmonic feature value of a vowel in a bidirectional harmony pattern depends on some bounded local segment *k*–1 segments away in either direction (e.g., rightward for prefixes and leftward for suffixes, in the case of bidirectional stem control). If a function does not increase the length of the string or introduce new markup symbols, Heinz & Lai (2013) prove that the composition of these subsequential mappings makes bidirectional harmonies *weakly deterministic*. A toy example of bidirectional

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stem-controlled harmony is exemplified in (4), where two functions, A and B, must apply to each of the strings, *w,* to generate the correct outputs.

(4)

| $w$ | /ba-√zi-ba/ | /be-√zɪ-be/ |
|---|---|---|
| $\overleftarrow{A}(w)$ | be-√zi-ba | ba-√zɪ-be |
| $\overleftarrow{A}(w)\circ\overrightarrow{B}(w)$ | be-√zi-be | ba-√zɪ-ba |

To analyze the harmony pattern in Tutrugbu, a right-subsequential function with $k$=3 must be composed with a left-subsequential function that uses two new symbols, [?] for [–high] vowels that might undergo harmony, and [¿] for [+high] vowels that might undergo harmony. These functions are modeled in (5), where the first, right-subsequential function, A, assigns the ATR value of the root to preceding [+high] prefix vowels. When this initial function encounters a [–high] vowel, it must mark that vowel and every subsequent vowel [?] or [¿], because [–high] vowels block harmony when a [+high] initial-syllable vowel is also present. The second, left-subsequential function, B, then assigns a [–ATR] value to every prefix vowel marked up with [?] or [¿] following a word-initial high vowel, and [+ATR] to all other vowels marked [?] or [¿].

(5)

| $w$ | /bʊ-tɪ́-ba-dɪ-√wu/ | /a-tɪ́-ba-ba-á-√wu/ |
|---|---|---|
| $\overleftarrow{A}(w)$ | b¿-t¿́-b?-di√wu | ?-t¿́-b?-b?-?́-√wu |
| $\overleftarrow{A}(w)\circ\overrightarrow{B}(w)$ | bʊ-tɪ́-ba-di-√wu | e-tí-be-be-é-√wu |

Since these two functions must introduce two new symbols into the alphabet, their composition is not weakly deterministic (Heinz & Lai 2013). Crucially, this parallels the composition of functions necessary to analyze so-called "sour grapes" harmony (Wilson 2003; Heinz & Lai 2013), which has been deemed pathological because unbounded harmony is typically myopic (Wilson 2003). Walker (2010) shows that bounded harmony patterns may be either myopic or non-myopic, and the facts of Tutrugbu demonstrate that unbounded harmony patterns may also be non-myopic.

In automata-theoretic terms, the finite state transducer for ATR harmony in Tutrugbu is non-deterministic, since the realization of a medial non-high prefix vowel depends on potentially unbounded look-ahead. This unbounded look-ahead strongly resembles the *circumambient unbounded* tonal processes discussed in Jardine (2016). Given the existence of tone spreading processes that necessarily reference unbounded distances on either side of a potential tone-spreading target, Jardine concludes that "tone is different" (see also Hyman 2011), and as a result that the subregular hypothesis applies only to segmental phonology. The pattern in Tutrugbu shows that vowel harmony, like tonal spreading, may depend on featural content an unbounded distance from a potential target.

Two other segmental counterexamples to the subregular hypothesis are known, Sanskrit *n*-retroflexion and Yaka height harmony (Jardine 2016). Ryan (2017) argues that the Sanskrit case depends on morphology, and the Yaka case is potentially analyzable in other terms (see Hyman 1998). The fact that Tutrugbu exhibits this complex phonological pattern suggests that phonology may only be *biased* toward computational and formal simplicity, but without any firm subregular boundary (see also Avcu 2017).

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