Multiple metathesis is strictly local: evidence from stress driven metathesis

Keywords: phonology, metathesis, computational linguistics, subregular languages

Overview This paper investigates the unique metathesis patterns found in Kwara'ae in which multiple metathesis operations are applied to a word. These patterns cannot be derived by Input Strictly Local (ISL) functions contrary to the previous claim that metathesis is ISL (Chandlee 2015). Instead, the pattern was found to be Output Strictly Local (OSL), but with an unusually large locality domain. I will show, however, that if such seemingly complex metathesis processes are factorized into smaller operations, we will be able to describe the pattern with ISL and sustain a relatively small locality domain. A computational analysis of Kwara'ae's metathesis patterns indicate that factorizing phonological processes into smaller operations is preferable since they together can produce computationally simpler processes.

Metathesis and input strictly local functions Kwara'ae, an Austronesian language, exhibits productive CV-metathesis. For instance, CV in the final syllable of a disyllabic word becomes transposed (e.g. /CV_1CV_2/ $\rightarrow$ CV_1V_2C) to make a monosyllabic word. This disyllabic pattern is identical to Rotuman CV-metathesis pattern which was used to demonstrate that CV-metathesis is Input Strictly Local (ISL) (Chandlee 2015).

Strictly Local functions examine a string from left to right and it rewrites the symbol based on previous n-symbols. For ISL, the output string depends on the previous n-symbols in the input while for Output Strictly Local (OSL) function, it will depend on the previous n-symbols in the output. (Chandlee 2014) For instance, for an Input Strictly 2-local function, an output element x is mapped from the input depending on the corresponding element in the input x and its preceding element. Chandlee (2014) shows that Rotuman CV-metathesis is 3-ISL since the output of metathesized VC sequence as in **??** depends on the sequence of **CV**$\ltimes$ ('**sa**$\ltimes$') and concludes that metathesis is ISL.

(1) ISL mapping for Rotuman metathesis

Input:	$\rtimes$h	o	**s**	**a**	$\ltimes$
			$\downarrow$	$\downarrow$	
Output:	$\rtimes$		ho	**as**	$\ltimes$

Note that simple metathesis in Kwara'ae's disyllabic word exhibits the same exact pattern as Rotuman, which renders the pattern 3-ISL as well. However, multiple metathesis in Kwara'ae reveals that the pattern cannot be described with ISL functions.

Multiple metathesis application What is special about Kwara'ae is that it exhibits cases of multiple metathesis application, in which more than one transposition of two segments are applied to a word. Such metathesis patterns make it impossible to model the pattern with ISL because it needs to know if metathesis operation has been applied to previous output elements. When a word such as /CVCVCVCV/ metathesizes to [CVCV.CVVC], two separate CV transpositions occur (Heinz 2004). However, odd-number-syllable input strings produce problematic metathesis patterns as shown in **??**.

(2) Kwara'ae's multiple metathesis examples takes from Heinz (2004)

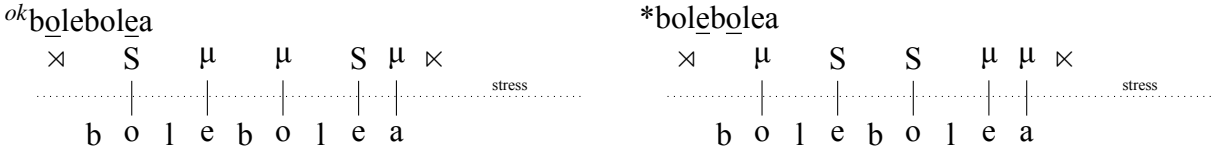
/CVCV<u>CV</u>/ (/lima<u>ku</u>/)	$\rightarrow$	[CVCV<u>VC</u>] (lima<u>uk</u>)
/CV<u>CV</u>CV<u>CV</u>/ (/ke<u>ta</u>la<u>ku</u>/)	$\rightarrow$	[CV<u>VC</u>CV<u>VC</u>] (ke<u>at</u>la<u>uk</u>)
/CV<u>CV</u>CVCV<u>CV</u>/ (/da<u>ro</u>ʔani<u>da</u>/)	$\rightarrow$	[CV<u>VC</u>CVCV<u>VC</u>] (da<u>or</u>ʔani<u>ɛd</u>)

These patterns show that examining the input string from the left edge for the **CV**$\ltimes$ sequence does not derive the correct pattern because it fails to derive an output with more than two metathesized sequences. The above examples also show that they cannot be ISL. Instead, the multiple metathesis patterns turn out to be OSL, since the output element depends partly on whether or not

the previous output elements underwent metathesis. This current paper reveals that Kwara'ae's multiple metathesis mapping is at least 5-OSL, which is an unusually large locality. Not only this treatment is counter-intuitive, the locality domain is much larger than anything we see comparable, which tends to be 2-OSL or 3-OSL(Chandlee 2014).

Stress patten of Kwara'ae and its interaction with metathesis The aforementioned problem can be solved by separating the stress assignment from its associated metathesis operation. By taking stress pattern into account, it is revealed that not only Kwara'ae's multiple metathesis is ISL again, but also it is incredibly simple. Kwara'ae's normal speech register, in which CV metathesis is observed, exhibits systematic stress patterns. Generally the initial syllable takes the primary stress while the syllable containing the penultimate mora takes the secondary stress, and additional secondary stress falls on an alternating mora leftward. With the stress specified in the input, ISL functions can correctly derive the output sequence. /CV̲CV̲CV/, where V̲ represents a stressed syllable, metathesizes to CV̲CV̲VC, and /CV̲CVCVCV̲CV/ to CV̲VCCVCV̲VC. Now, 3-ISL function can easily derive the metathesis pattern since it only needs to look for V̲CV sequence in the input. What this shows is that how you factorize the grammar into different sub-processes really matters especially when attempting to describe seemingly complex phonological patterns.

Stress pattern of Kwara'ae also turns out to be very simple. It belongs to Tier-based Strictly Local (TSL) phenomena which have independently been argued for in the literature (Heinz 2011, 2015). In TSL, elements of a string sharing certain features can be projected onto a tier to check their well-formedness independently from the original string. This allows the grammar to capture patterns involving non-local dependencies. For example, to capture the stress pattern of Normal register in Kwara'ae, we can project both stressed moras (S) and unstressed moras (μ) on the tier to see if illegal sequences are found on the tier. The following diagrams show a grammatical /bolebolea/ → [bo̲lebolea̲] stress pattern, containing stressed o̲ and e̲, as well as an example of an ungrammatical pattern *[bole̲bo̲lea].



The correct stress pattern is derived by excluding output forms containing the sequences *SSS, *⋊μ, *μμ⋉, *μμμ, *S⋉ *SSμμ, *SSμS, or *μSS on the tier. As shown above, since an μSS sequence on the stress tier is prohibited, the ungrammatical pattern *[bole̲bo̲lea] does not surface.

Conclusion This paper provides a careful computational analysis of multiple metathesis patterns as found in Kwara'ae and offers modifications to previously proposed computational analyses on metathesis. By feeding an input sequence with the correctly assigned stress, 3-ISL function will be able to correctly characterize metathesis patterns in Kwara'ae, which would otherwise be impossible to be modeled by ISL. The analysis provided in the paper argues for factorization of the grammar into different sub-processes, which makes it possible to produce simpler computational processes of phonological patterns.

Chandlee, J. 2014. *Strictly local phonological processes.* PhD Thesis, University of Delaware • **Chandlee**, J. 2015. *Explaining Phonological Typology: Phonetic and Computational Factors.* Presentation at Reed College, Portland, OR, April 17. • **Heinz**, J. 2004. *CV Metathesis in Kwara'ae.* MA Thesis, UCLA • **Heinz**, J., **Chetan** Rawal, and **Herbert** G. Tanner. 2011. Tier-based strictly local constraints in phonology. In *Proceedings of the 49th Annual Meeting of ACL*, 58–64. • **Heinz**, J. 2015. The computational nature of phonological generalization. *Ms., University of Delaware*.