Tonal exchange rules in Khoekhoe:
The role of defective nodes and prosodic subcategorization

§1 Summary In Khoekhoe, causative morphology adds a mid tone (M) to a stem if it lacks one, but deletes a M if the stem already has one (e.g. L→LM, but LM→L). We interpret this as a classic exchange rule, and analyze exchange as due to a defective tonal root node coupled with prosodic subcategorization. This study supports Generalized Nonlinear Affixation (Bermúdez-Otero 2012, Trommer & Zimmermann 2014, *inter alia*), whereby complex alternations ultimately originate from distinct underlying representations, and not specialized auxiliary mechanisms.

§2 Exchange rules and tone Exchange rules – also called 'toggling', 'reversals', or simply 'polarity' (see, *inter alia*, Gregersen 1972, Anderson & Browne 1973, Baerman 2007) – refer to morphophonological patterns where inputs with a feature [-F] become [+F], but in the exact same context inputs with [+F] become [-F]. Recently, there has been renewed debate as to whether exchange rules can be generated by grammars without a dedicated exchange mechanism (DiCanio *et al.* 2020, de Lacy 2020). Surprisingly, however, tone has played only a marginal role in this literature, with few exceptions (e.g. Yue-Hashimoto 1986, Mortensen 2006). This paper seeks to incorporate an overlooked case of tonal exchange from Khoekhoe into this ongoing dialogue.

§3 Khoekhoe data Khoekhoe [naq] (traditionally classified as 'Khoisan') is a major language of Namibia, whose tone system has been extensively documented and analyzed (Beach 1938, Hagman 1977, Haacke 1999, Brugman 2009, Kusmer 2019). There is consensus that the tone system involves four pitch heights which combine to form six primary melodies distributed across a bimoraic lexical stem. A minimal pair is in (1). We provide the informal label for each melody from the Khoekhoe literature, the citation form of the word, and its approximate pitch numerically (4 = highest, 1 = lowest). Other logically possible stem melodies are either marginal or unattested.

These six melodies form three pairs (1a vs. 1b vs. 1c), based on their behavior in two morphophonological contexts (2). One context is 'neutralizing flip-flop' where the melodies of the pair neutralize, idiosyncratically triggered by several derivational suffixes, e.g. the applicative suffix **-bȁ** in (4). Here, the [12] melody ('Double-Low') and [13] melody ('Low-Rising') from (1c) both become [13]. Comparable neutralization affects the other two pairs as well (i.e. 1a and 1b). The other context is 'exchanging flip flop', which is consistently triggered by causative reduplication, in (5). Here, the members of each pair from (1) appear with the other's melody: the stem in (5a) is [12] in citation but becomes [13], while the stem in (5b) is [13] but becomes [12].

(1)	Melody label	Citation (Haacke 2008:158)				(2) Exch.	Neut.	(3)	Our phonological analysis			
a.	'Double-High'	**!'őḿ.s**	'fist'	[43]	→	[24]	[24]	a.	/**H**/	→	**MH**	**MH**
	'High-Rising'	**!'òm̋.s**	'pollard'	[24]	→	[43]	[24]		/**MH**/	→	**H**	**MH**
b.	'High'	**!'óm̀**	'coagulate'	[32]	→	[22]	[22]	b.	/∅/	→	**M**	**M**
	'Low'	**!'òm̀**	'force out'	[22]	→	[32]	[22]		/**M**/	→	∅	**M**
c.	'Double-Low'	**!'ȍm̀**	'push'	[12]	→	[13]	[13]	c.	/**L**/	→	**LM**	**LM**
	'Low-Rising'	**!'ȍḿ.s**	'udder'	[13]	→	[12]	[13]		/**LM**/	→	**L**	**LM**

(4) Neutralizing flip-flop: E.g. triggered by applicative **-bȁ** (Haacke 1999:142)
a. 'Double-Low' [12] → 'Low-Rising' [13]: [**!nȁrì**] 'drive' → [**!nȁrí-bȁ**] 'drive for'
b. 'Low-Rising' [13] → 'Low-Rising' [13]: [**ȕrí**] 'jump' → [**ȕrí-bȁ**] 'jump for'

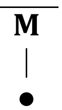
(5) Exchanging flip-flop: E.g. triggered by causative reduplicant -◌◌ (Brugman 2009:164)
a. 'Double-Low' [12] → 'Low-Rising' [13]: [**|nȁm̀**] 'love' → [**|nȁḿ-|nȁm̏**] 'inspire to love'
b. 'Low-Rising' [13] → 'Double-Low' [12]: [**!nȕβú**] 'short' → [**!nȕβù-!nȕβȕ**] 'shorten'

While the numeric renditions of the six melodies in (1) are phonetically accurate, we posit a much simpler phonological analysis, in (3) above (building on Nakagawa 2006 for a sister language G|ui): there are three tonemes **H**, **M**, and **L** which may combine to form 'one-step' rising contours (i.e. **LM** and **MH**). We deviate from all other Khoekhoe specialists in our treatment of the 'High' melody [32], which we take to be tonally unspecified (i.e. /∅/). At phonetic implementation, its citation form is realized at a pitch between the **H** toneme (i.e. [43]) and **M** toneme (i.e. [22]).

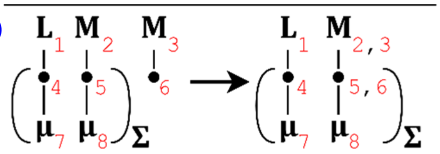
Under our analysis, neutralizing flip-flop amounts to the addition of a **M** toneme (subject to constraints on falling melodies in the lexical tonology), which thereby neutralizes the three pairs (3a-c). In contrast, exchanging flip-flop constitutes an exchange rule: melodies which lack **M** add it, but those which have **M** already delete it. Our phonological analysis thus provides a principled reason why the melodies form the three pairs observed, and for the direction they neutralize to.

§4 Exchange via defective root nodes To capture the contrast between the two flip-flops, we posit two types of floating tone representations. One is simply a 'floating' **M** associated to a standard tonal root node (TRN – Snider 1999), represented as ● in (6). This type is found in the neutralizing flip-flop contexts, schematized in (7)-(8). A floating **M**—● coalesces with a stem **M** if present (7), but in inputs without a stem **M** the floating **M**—● simply docks to a stem mora (8). Note the numbers in red represent correspondence relations between the input and output.

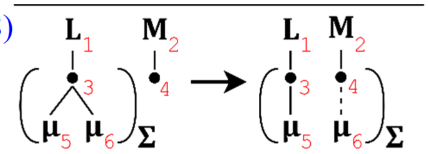
(6) Standard TRN (●): (Neutralizing FF contexts)



(7)



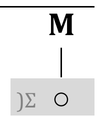
(8)



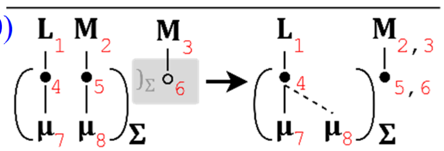
In contrast, floating **M**'s in exchanging contexts have two representational differences. First, they involve a defective TRN, represented as ○ in (9). One could view the defective node as (inherently) phonetically uninterpretable *à la* Containment Theory (Prince & Smolensky 1993), as a value approaching zero *à la* Gradient Symbolic Representation (Smolensky & Goldrick 2016), or as a special 'phantom' node *à la* Phantom Structure (Rolle & Lionnet 2020). Crucially, in all implementations the defective ○ is qualitatively distinct from non-defective ●, and not simply defective because it is under- or over-specified for certain features (cf. Bye & Svenonius 2012).

Second, this defective node prosodically subcategorizes (Bennett *et al.* 2018, *inter alia*) to be right-adjacent and external to a prosodic stem (Σ – Downing & Kadenge 2020). This is underlyingly represented as the gray $)_\Sigma$ boundary in (9). Independently, a constituent Σ accounts for many phonotactic distributions in Khoekhoe and 'Khoisan' generally (Nakagawa *et al.* 2023).

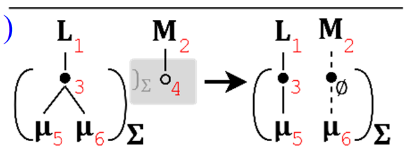
(9) Defective TRN (○): (Exchanging FF contexts)



(10)



(11)



Schematic input→output derivations with a defective node ○ are in (10)-(11). In order to satisfy output well-formedness, a toneme must associate to a non-defective TRN (i.e. ●). The stem **M** in (10) coalesces with the floating **M**—○, thereby satisfying this well-formedness. Unlike in neutralizing FF (7), though, coalescence occurs outside of the stem in order to satisfy the prosodic subcategorization of the defective ○. If we assume that TRN-to-mora association (i.e. ●—μ) cannot cross a prosodic stem boundary, then the resultant floating **M**—● is left unincorporated. It subsequently deletes at the next cycle, via Stray Erasure (Steriade 1982) or its equivalent.

Finally, if no stem **M** exists (11) then there is no node with which **M**—○ may coalesce (without violating other faithfulness constraints). In order for the floating **M** to associate to a non-defective TRN, an epenthetic node must be inserted instead (denoted $●_\varnothing$ in 11). Because this node is epenthetic, it lacks the subcategorization requirements of the ○, and may appear stem-internally.

§5 Model comparison We close our paper by discussing one final empirical fact which supports Generalized Nonlinear Affixation (**§1**): flip-flop is blocked if the trigger is not directly adjacent to the prosodic stem (Haacke 1999). Because our analysis of exchange involves overt substance (i.e. floating tones, nodes), we may attribute such data quirks to adjacency relations and autosegmental association. In contrast, such data are problematic for alternatives without overt floating material (e.g. transderivational anti-faithfulness – Alderete 2001, DiCanio *et al.* 2020).