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Phonological Processes in the Acquisition of Kiswahili: An Optimality Theory Perspective

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Abstract
In the acquisition of any language, the child is faced with multiple challenges. Among these is segmenting a continuous stream of speech into individual sound segments and articulating consonant clusters and polysyllabic words. Due to limitations of cognitive and physiological development, the child has to simplify the acquisition task via alternations and changes to the adult input. This may naturally lead to a number of phonological processes. However, the attested phonological processes differ from language to language and from one child to another. The objective of this study was to address these issues by examining phonological process that accompany the acquisition of Kiswahili phonemic inventory and the syllable structure. The paper is based on data from a longitudinal study of two siblings from one year up to five years of age. The two subjects were purposefully sampled and the data collected by using parental diary, an audio-recorder and a word list. Couched within the Optimality Theory (OT; Prince & Smolensky, 2004), the data was analyzed in conventional OT tableaux. The optimal output was assessed through comparative evaluation of harmony based on Kiswahili specific constraint hierarchy. The findings indicate that transitional grammars exhibit different phonological processes at different stages as the child re-ranks the constraints to approximate to the adult norm. Children initially rank markedness constraints above the faithfulness constraints which results in alternations and therefore, phonological processes that ease the task of acquisition. In this process, the output is typically the unmarked forms that are simpler in structure, easier to produce and perceive and thus, easier to acquire. These processes reduce and ultimately disappear as the child demotes the markedness constraints below the faithfulness constraints attaining adult-like phonologies.
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1. Introduction

Clark (2003:1) begins her work by making a telling statement "Language is quintessentially human" arguing that language pervades all spheres of our life in the sense that it is unimaginable to do anything without the use of language. In the same vein, Lust (2007:1) puts it very candidly that "nothing is more specifically 'human' than the knowledge of language". Yet they both agree that language is a complex system and that children are faced with a difficult task unlike learning how to walk or dress up. A language has a complex system of sounds, sound combinations, word structure and syntactic constructions. In addition, languages differ in many ways both in range, scope and variations at all levels. They do differ in what is easier and hard to learn (markedness per see), that is, their conceptual and formal complexity.

However, there is a general consensus that children acquire their first language so fast regardless of the language or their environment and this is achieved in the absence of both instruction and negative feedback. In addition, the input from adults has been described as 'degenerate or impoverished' summed up by Generative linguists as 'the poverty of the stimulus' as a rebuke of the Behaviourist view of the role of input. The achievement by children is aptly summed up by Lust (2007:1) that it is "doubtless the greatest intellectual feat any of us is ever required to perform". This feat was recognized quite early among linguists and linguistic theories have sought to model and capture the ease of first language acquisition in different theories and models.

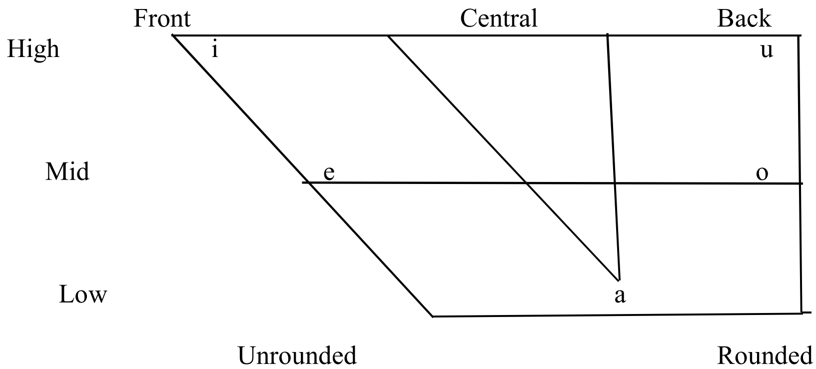
The early Behaviourist approach argued that children acquired language via imitation and that the input played a critical role and not the child's internal processing mechanisms. This was dismissed by Generative phonologists who asserted that language acquisition must be pre-determined innately and that the errors made by children show internal hypothesis testing and could not be imitations of the adults (cf. *goed* for *went*). Generative phonologist proposed re-write rules that map underlying representations on to surface forms (Smith, 1973). Language acquisition was portrayed as a rule learning process. However, rules had myriad shortcomings such as rule ordering paradoxes, rule duplication and production of non-recurrent forms. Often, more rules were ascribed to the child than the adult, contrary to the very concept of 'ease of acquisition'. As a rejoinder, Natural Generative Phonology (NGP) proposed to replace rules with 'processes' (Stampe, 1973), in that natural processes would be easier to acquire than the un-natural rules. Yet natural generativists introduced a new level of representation in child's mapping making it more complex. Similarly, not all aspects of acquisition could be ascribed to natural processes.

The generative grammarians reformulated rules turning them into 'Principles and Parameters' (Chomsky, 1999). The basic argument was that principles are universal; part of Universal Grammar (UG) and these are given to the child for free as part of the biological endowment that enables them learn any language. The task of the child is to learn the parameters alone which come in binary form with a default setting until there is evidence to the contrary. In other words, the child's task is simple like switching 'on' and 'off'. However, this was soon seen as inadequate in accounting for the rapidity with which children acquired their first language. Parameters could only account for acquisition of binary features yet language is too complex to be reducible to parametrization. Due to these shortcomings, the constrained-based approach emerged and has gained currency since the late 1990s (Hayes, 2004; Fikkert, 2007).

In Optimality Theory (hereafter OT; Prince & Smolensky, 2004) a language is a system of conflicting constraints. These constraints are universal and are ranked in a language specific hierarchy. Language acquisition is a process of constraint re-ranking based on evidence from the target or ambient language (Fikkert & de Hoop, 2009). The child is able to acquire a language fast enough because he has the easy task of re-ranking universal constraints. Initially, the child ranks the markedness constraints above the faithfulness constraints producing the 'unmarked' forms that are simpler and easier to acquire. In the current study, it is argued that phonological processes are set in motion when markedness constraints initiate change on the surface forms of sounds and the syllable structures to make them 'unmarked'. These processes produce structures that are easy to produce or perceive, common, usual or simpler, among other variables. This may lead to assimilation, neutralization, and harmony besides other processes that make acquisition task less daunting for the child.

However, because children use different strategies, and therefore, different phonological process to overcome difficult structures, this study examined two children to note similarities and variations in the attested phonological processes. Similarly, the study examined Kiswahili, a Bantu language spoken in east and central Africa to gauge if the predictions of OT as a typological theory are credible with respect to the role of markedness constraints in engendering phonological process. The study assumes the following phonemic inventory of the language. Standard Kiswahili has five pure vowels and five long counterparts of the same (ten monophthongs) as follows; /a/, /e/, /i/, /o/ and /u/ on one hand, and /a:/, /e:/, /i:/, /o:/ and /u:/ for the long vowels respectively. Kiswahili is a three-height vowel system and the vowel phonemes are plotted in the following vowel chart.

Table1: Kiswahili Vowels



The language has thirty consonants spread across eight different places of articulation as follows; bilabials: /p/, /b/, /m/, /^{m}b/; labio-dentals: /f/, /v/; interdentals: /θ/, /ð/; alveolars: /t/, /d/, /n/, /l/, /r/, /s/, /z/, /^{n}d/, /^{n}z/; post-alveolar: /ʃ/; palatals: /c/, /ɟ/, /ɲ/, /j/, /^{ɲ}ɟ/; velars: /k/, /g/, /ɣ/, /ŋ/, /^{ŋ}g/; labio-velar /w/ and one glottal phoneme /h/. Note that the five prenasalised consonants are phonemic (contrastive) in the language. (cf. Chacha, 2007, for an argument to include them in the IPA alphabet). These consonants are plotted in a conventional consonant chart as shown in Table 2.

Table 2: Kiswahili Consonants (Mgullu 2001), adapted with modification.

	Bilabial	Labio-dental	Inter-dental	Alveolar	Post-alveolar	Palatal	Velar	Glottal
Plosives	p b			t d		c ɟ	k g	
Fricatives		f v	θ ð	s z	ʃ		ɣ	h
Nasals	m			n		ɲ	ŋ	
Liquids				l, r				
Glides						j	w	
Pre-nasals	^{m}b			^{n}d, ^{n}z		^{ɲ}ɟ	^{ŋ}g	

Note that some authors (cf. Mgullu, 2001:67) transcribe initial sounds in ***chuma*** **'**steel' and ***juma*** 'week' as affricates [ʧ] and [ʤ] due to English influence in orthography and pronunciation. In this study, they are transcribed as [c] and [ɟ] because in Bantu, they are voiceless and voiced plosives based on nasal place assimilation and patterning (they pattern with other plosives, as observed in acquisition). Similarly, unassimilated (not fully nativized) Arabic loanwords that have non-Bantu syllable structure, are not included in the data. This paper is organized as follows; section 2 describes the data and methods, section 3 provides the analysis, section 4 the results and discussion and finally, section 5 provides the conclusion.

2.0 Data and Methods

The data for the study was collected from two children acquiring Kiswahili as their first language over a period of time in a longitudinal study. The data was collected for a period of four years beginning from one year of age up to the period when the subjects attained five years of age, a period considered to exhibit adult-like grammars.

2.1Participants

The participants who provided data were two female children as subjects. They are siblings and were coded as MS1 for the first born and MS2 for the second born. They had no known neurophysiological disorders nor language-speech pathology or impairment. Their developmental milestones were in the normal range and similarly, their cognitive development. They were exposed to Kiswahili language right from birth up to their pre-school years. During this period, they constantly had three main interlocutors; their parents (both teachers) and a caregiver. The three mainly spoke Kiswahili in the presence of the two subjects. Their playmates and neighbours used Kiswahili because of the cosmopolitan nature of the neighbourhood. Both their rural and urban homes were inhabited by speakers of different Kenyan languages making Kiswahili the de facto lingua franca. The language used at home and outside the home environment was Kiswahili except in school where English was used alongside Kiswahili. Note that the two children were two years apart; the elder was three years when the younger was one year old hence the duration of the study was six years. During the entire study, the participants were not aware of being studied.

2.2 Data Collection

Data collected was both in the form of audio and text (written text) collected over a period of four years for each subject. Speech tokens were recorded when the subjects are engaged in natural conversation at home. They were not aware of being observed or recorded. Two main instruments were used; parental diary and audio recorder. Parental diary recorded any observable change and speech of interest in the utterances of the children. This tool was used as need arises noting the date, time and context of the utterance and any accompanying paralinguistic cues. The audio recording was done every fortnight strictly at home preferably in the house.

Similarly, the recording parent could ask questions that leads to specific responses containing the target sounds, syllables or prosodic words. The audio files were transferred to the **Praat** software (Boersma & Weenick, 2015) for verification of the speech based on phonetic features such as formant values of vowels and spectrographic characteristics of consonants such as Voice Onset Time (VOT) in plosives. However, because this is purely a phonological study, no acoustic speech analysis was done.

A third tool, a syllable/word list, supplemented the two tools mentioned above. The word list was generated from the parental diary and audio recorder. In this case, the parent asked the children to repeat specific words through prompting. This was done as a basis for verification of the children's utterances and confirm if there are any or existing variations in the child's output. Table (3), is a sample of the subject's data. Seven stages are identified in the development path of the subjects.

Each stage is indicated by an initial Y (for Year) followed by numerals; the first indicates the year and the second, the month (typically, 6 months). This is because previous studies have indicated that it is only after about six months that there is noticeable difference in transitional grammar. However, after three years, most sounds and syllables are generally acquired and noticeable progress is only visible after about a year. In the data, the stages from three years follow this pattern (a year apart; Y3, Y4, Y5) as indicators of developmental milestones. Note that [-] implies the child has acquired the token form in the previous stage (s). Note also that at five years of age, the subjects could not produce the voiced fricatives [ð] and [ɣ].

Table 3: Sample Data

Tokens	Y1	Y1:6	Y2	Y2:6	Y3	Y4	Y5
[sa.fi]	[pi]	[api]	[capi]	[ʃapi]	[sapi]	[safi]	[-]
[ga.ri]	[ji]	[aji]	[jaji]	[kaji]	[kali]	[gali]	[gari]
[ba.ba]	[papa]	[papa]	[baba]	[-]	[-]	[-]	[-]
[me.za]	[me]	[meca]	[meca]	[meʃa]	[mesa]	[meza]	[-]
[ða.^{m}bi]	[pi]	[api]	[tapi]	[tabi]	[ta^{m}bi]	[da^{m}bi]	[θa^{m}bi]
[ka.li]	[ji]	[jaji]	[jaji]	[kaji]	[kali]	[-]	[-]
[ɣa.li]	[ji]	[jaji]	[jaji]	[kaji]	[kali]	[gali]	[gali]
[m̩.to.to]	[to]	[toto]	[itoto]	[mutoto]	[mutoto]	[mutoto]	[mutoto]
[mwa.na]	[ma]	[mama]	[mana]	[ana]	[muwana]	[muana]	[mwana]
[a.ca]	[ja]	[jaca]	[aca]	[-]	[-]	[-]	[-]
[hu.ju]	[u]	[u.u]	[ju:]	[juju]	[uju]	[uju]	[huyu]
[ɲu.^{m}ba]	[pa]	[jupa]	[uba]	[u:ba]	[u:^{m}ba]	[[ɲu^{m}ba]	[-]
[si.mu]	[mu]	[imu]	[[timu]	[cimu]	[ʃimu]	[simu]	[-]

3.0 Data Analysis

The child data were analyzed using OT formalism (McCarthy, 2004). First, the constraints were identified for each emergent phonological process, then the Kiswahili specific constraint hierarchy was determined and, finally, a comparative evaluation of the optimal candidate (the attested output form produced by the subjects). The paper assumes some basic understanding of OT architecture by the reader, especially with regard to constraint identification, their ranking, construction of the tableaux and evaluation of candidature harmony. In the analysis, the standard IPA conventions are adopted in which prosodic words are given broad (phonological) and not the narrow (phonetic) transcription. Some symbols may only be available from the Extended IPA chart (IPA, 2015).

3.1 Phonological Processes in Phonemic Inventory Acquisition

Table 4a provides the adult input data while Table 4b provides a summary of the different manifestations of substitutions in the child's phonemic inventory and the specific output phonological processes that follow from the substitutions at different stages. In Table 4b, it is apparent that the most pervasive alternations in child acquisition of the phonemic inventory is substitutions. Phonemes that are not yet acquired are substituted with those that have already been acquired. Similarly, phonemes that are difficult to articulate or partially acquired are substituted with those that are easier. Note: Syllable break is indicated by a period per the IPA notation.

Table 4a: Adult input data

sn	Input	Output	English Gloss	Input	Output	English Gloss
1	/baba/	[ba.ba]	father	/safi/	[sa.fi]	clean
2	/titi/	[ti.ti]	breast	/kula/	[ku.la]	eat
3	/mtoto/	[m̩.to.to]	a child	/dudu/	[du.du]	insect
4	/kali/	[ka.li]	sharp	/lala/	[la.la]	sleep (v)
5	/ka:/	[ka:]	sit	/ɣali/	[ɣa.li]	expensive
6	/gari/	[ga.ri]	a vehicle	/ŋo^{m}be/	[ŋo.^{m}be]	a cow
7	/simu/	[si.mu]	telephone (N)	/meza/	[me.za]	swallow
8	/ɲu^{m}ba/	[ɲu.^{m}ba]	a house	/ða^{m}bi/	[ða.^{m}bi]	sin (N)

Table 4b: Inventory emergent phonological processes

sn	Data 1	Data 2	Process	Motivation
1	/baba/-[papa]	/safi/-[sapi]	Fortition	Avoid unacquired sound
2	/titi/ - [θiθi]	/kula/-[kuja]	Lenition	Reduce constriction
3	/mtoto/- [θoθo]	/dudu/-[θuθu]	Spirantization	Lessen stricture
4	/kali/ - [kaji]	/lala/-[jaja]	Delateralization	Avoid laterals
5	/ŋo^{m}be/-[jope]	/ɲu^{m}ba/-[jupa]	Denasalization	Avoid unacquired nasals
6	/simu/-[timu]	/ða^{m}bi/-[tapi]	Stopping	Avoid fricatives
7	/ka:/ - [ja:]	/ɣali/ - [jaji]	Fronting/gliding	Avoid marked dorsals
8	/gari/ - [kali]	/ɣali/ -[kali]	Neutralization	Avoid voiced dorsals
9	/meza/ - [mesa]	/baba/ - [papa]	Devoicing	Avoid voiced sounds

From the data, it is evident that substitutions result in many phonological processes meant to ease the burden of acquisition. When a child is confronted with a sound that is not yet acquired, difficult or marked (on some phonetic-phonological dimension), the easiest option is to substitute that phoneme with one that is already part of the child's inventory or one that is easier to produce. Note that neutralization may be a cover term for all forms of substitutions if the resulting outputs obviates any contrast among the phonemes (phonemes are so referred only if they are contrastive/distinctive in a language). In fact, devoicing is a special form of neutralization (laryngeal neutralization) when the contrast between the voiced and voiceless obstruent is lost.

What follows is an analysis of these processes showing what constraints are involved, their ranking and interaction in determining the optimal form of the emergent grammars of the subjects at a particular stage. We shall consider fortition, delateralization, devoicing and neutralization for analysis in the tableaux. In fortition, also known as strengthening, a weak sound strengthens into a strong sound based on a universal strength scale (Parker, 2002) which can be relativized to specific languages. A Kiswahili consonant strength scale could be invoked as shown in the following figure 1 based on universal parameters of degree of constriction and voicing.

Figure 1: Kiswahili phonemic strength scale

/k, c, t, p/ > /g, ɟ, d, b/ > /^{ŋ}g, ^{ɲ}ɟ, ^{n}d, ^{m}b/ > /h, ʃ, s, θ, f/ > /ɣ, z, ð, v/ > /^{n}z/ > /ŋ, ɲ, n, m/ > /l, r/ > /j, w/

Fortition (strengthening) Lenition (weakening)

Whenever a sound on the right side is substituted by one from the left, that process is referred to as fortition or strengthening which turns a weak sound into a strong sound. The reverse is also true, turning strong sounds into weak ones is called lenition or weakening. Similarly, the strength scale is the inverse of the sonority scale (strong sounds have low sonority and vice versa (Parker, 2002). In essence, spirantization which turns stops into fricatives is a lenition process while stopping, which turns fricatives into pure stops (plosives) is a fortition process.

In OT, fortition must be driven by some markedness constraints ranked over some faithfulness constraints. In /safi/ →[sapi], a fricative is turned into a stop (stopping). It is proposed that a constraint against voiced obstruents (*OBS$_{\mathrm{VOI}}$) and against fricatives (*OBST$_{\mathrm{CONT}}$) (here combined as *OBS$_{\mathrm{VOI,\ CONT}}$) are relevant in assessing harmony. However, because children acquire the phonemic inventory in specific words and not in isolation, constraints that are applicable at the prosodic level will be included. Therefore, we include constraints that demanding onset consonants in syllables; (ONSET) and another banning coda consonants (*CODA). They both dominate MAX-IO, that forbids deletion, DEP-IO, that forbids insertion or epenthesis, IDENT-IO, that forbids feature disparity between input and output and finally, INDENT$_{\mathrm{CONT,}}$ that demands input continuant features (in fricatives) to be maintained in the output (McCarthy, 2004). The ranking of these constraints is; ONSET, *CODA, *OBS$_{\mathrm{VOI}}$ ≫MAX-IO, DEP-IO, ≫IDENT$_{\mathrm{CONT.}}$ Their interaction is shown in tableau 1.

Tableau 1: /safi/ → [sapi] 'clean'

/safi/	ONSET	*CODA	*OBS$_{\mathrm{VOI/CONT}}$	MAX-IO	DEP-IO	IDENT-IO$_{\mathrm{CONT}}$
a. ☞[sa.pi]						*
b. [sa.fi]			*!			
c. [sap]		*!		*		*
d. [a.pi]	*!			*		*
e. [pi]				*!*		*

Given the input [safi], the optimal candidate is [sapi] in which the voiceless fricative is substituted by a voiceless plosive. *OBS$_{\mathrm{CONT}}$ induce the violation of the low ranked IDENT$_{\mathrm{CONT}}$. Note that monosyllabic [pi] which is optimal at year one stage is no longer optimal because MAX-IO has been promoted above IDENT-IO (CONT). However, turning /f/ into /p/ in the presence of /s/ another fricative is a typical case of dissimilation. In the above tableaux, there is no crucial ranking between the undominated constraints in the hierarchy, reversing them does not affect the results. Similarly, delateralization is caused by markedness against lateral liquids (*LATERAL) dominating faithfulness constraints ranked thus; ONSET, *CODA, *LATERAL≫ MAX-IO, DEP-IO ≫ IDENT-IO (LAT).

Tableau 2a: /kali/ → [kaji] 'sharp, harsh'

/kali/	ONSET	*CODA	*LATERAL	MAX-IO	DEP-IO	IDENT-$_{\mathrm{LAT}}$
a. ☞[kaji]						*
b. [kali]			*!			
c. [kaj]		*!		*		*
d. [aji]	*!			*		*
e. [ji]				*!*		

In addition, when exposed to /gari/ 'vehicle' the subjects first produced [ji] followed by [jaji], [kaji], [kali] [gali]and finally, [gari] showing the order [j] → [k] → [g] → [l] →[r]. Universal constraint against dorsal consonants *DORSAL initially rules out /k/ and /g/ then the more specific markedness constraint against liquid sounds; *LIQUID which must dominate markedness constraint against coronal glide; *GLIDE$_{\mathrm{COR}}$ ranked in the constraint hierarchy thus; ONSET, *DORSAL, *LIQUID ≫ *GLIDE$_{\mathrm{CORONAL}}$ ≫ MAX-IO ≫ IDENT$_{\mathrm{LATERAL/VOWEL}}$ as follows;

Tableau 2b: /gari/ → [ji] 'vehicle'

/gari/	ONSET	*DORSAL	*LIQUID	*GLIDE$_{COR}$	MAX-IO	IDENT-IO$_{LAT/V}$
a. ☞[ji]				*	**	*
b. [gari]		*!	*			
c. [kali]		*!	*			
d. [ja]				*	**	**!

The optimal candidate incurs the least violations. Note the relevance of constraint ranking because candidate (d) must lose to (a) in substituting the input vowel [i] with output [a]; a vocalic identity violation. At five years, the subjects had acquired both the voiced velar plosive /g/ and the voiced alveolar trill /r/ sound, it is assumed that the subjects had demoted all the markedness constraints below the MAX-IO, except the ONSET constraint. Similarly, the IDENT-IO family of constraints, were subsequently promoted above the markedness constraints in the hierarchy as shown in tableau 2c that follows in which both sounds are faithfully mapped on the surface.

Tableau 2c: /gari/ → [gari] 'vehicle'

/gari/	ONSET	IDENT$_{DOR/VOI}$	IDENT$_{LIQ}$	MAX-IO	*LIQUID	*DOR
a.☞[gari]					*	*
b. [ji]			*!	**		
c. [kali]		*!			*	*
d. [a]	*!			***		

Tableau 3: /baba/ → [papa] 'father'

/baba/	ONSET	*CODA	*OBS$_{[VOI]}$	MAX-IO	DEP-IO	IDENT-$_{VOI}$
a. ☞[papa]						**
b. [baba]			*!*			
c. [apa]	*!			*		*
d. [pap]		*!		*		**
e. [pa]				*!*		*

The most harmonic candidate is one with the two consonants devoiced. The adult input with two voiced plosives is ruled out by the child's constraint ranking at this stage in which *OBS$_{VOI}$ is an undominated constraint whose violation is fatal. The same result would be obtained for the input-output forms such as /meza/ → [mesa] 'swallow' and /ða^{m}bi/ → [tapi] 'sin' in which the voiced obstruents are typically devoiced in the initial stages of the acquisition process (*see* data table 3, above).

In neutralization, the contrast that exists between lexemes is lost so that two or more output forms are realized the same although the inputs are different and have different meanings in the language. In our data, three inputs; /kali/ 'harsh/sharp', /gari/ 'vehicle' and [ɣali/ 'expensive' are all realized as [kali] on the surface at age three in the subject's production grammars. This is also a form of semantic neutralization due to phonological laryngeal neutralization of voicing in which the voice contrast is lost. In the data, the source of neutralization is actually other phonological processes; stopping and devoicing, mentioned above. This implies that constraints proposed for the two processes are responsible for neutralization (laryngeal and manner of articulation neutralization). *OBS$_{VOI}$ will be undominated in the constraint hierarchy alongside a new constraint *TRILL. In two tableaux (4 & 5), we examine two inputs; /gari/ 'vehicle' and /ɣali/ 'expensive' all mapped on to [ka.li] at three years.

Note that at this stage IDENT-LIQUID has been promoted above *LIQUID hence the palatal glide is no longer optimal (*[ka.ji]). In addition, it is assumed that *CODA constraint remains undominated in constraint hierarchy because Bantu languages typically have open syllables only

Tableau 4: /gari/ →[kali]'vehicle'

/gari/	ONSET	*TRILL	*OBS$_{[VOI]}$	MAX-IO	IDENT-$_{TRILL}$	IDENT-$_{VOI}$
a. ☞[kali]					*	*
b. [gari]		*!	*			
c. [ali]	*!			*	*	
d. [kari]		*!				*
e. [ka]				*!*		*

Note that at this stage IDENT-LIQUID has been promoted above *LIQUID hence the palatal glide is no longer optimal (*[ka.ji]). In addition, it is assumed that *CODA constraint remains undominated in constraint hierarchy because Bantu languages typically have open syllables only. Similarly, neutralization observed in /ɣali/→[kali] 'expensive', is due to the same constraint ranking only that the markedness constraint *TRILL, is no longer relevant in the evaluation of harmony. Instead, we introduce a faithfulness constraint that militates against feature change from [+continuant] to [-continuant] but is low ranked because it is violated by the optimal candidate.

The phoneme [ɣ] is a velar fricative hence [+CONT] while the substitute [k] is [-CONT].

Tableau 5: /ɣali/ → [kali] 'expensive'

//ɣali/	ONSET	*CODA	*OBS[VOI]	MAX-IO	IDENT-CONT	IDENT-VOI
a. ☞[kali]					*	*
b. [/ɣali/]			*!			
c. [ali]	*!			*		
d. [kal]		*!		*	*	*
e. [ka]				*!*	*	*

The optimal candidate is one that has undergone neutralization due to the top ranked markedness constraint against voiced obstruents at the expense of fidelity to the underlying input form.

At this point in the analysis, it is apparent that all forms of substitutions in terms of fortition, delateralization, devoicing and neutralization are a result of markedness constraints dominating specific faithfulness constraints. This triggers the aforementioned phonological process that alters the input such that the resultant output is easier for the child to acquire. It is noteworthy that the same constraints responsible for devoicing are also involved in voice neutralization which points to the efficacy of the theory in accounting for related phonological processes.

3.3 Syllable-based Phonological Processes

In the child acquisition data (Table 4d), it is observed that the adult syllable structure is modified to fit the child's concept of 'canonical' or universal syllable structure. The child's output syllable exhibits various alternation that mainly involved simplification of consonant clusters in the onset, avoidance of syllables with unacquired or difficult onsets and those with syllabic consonants in the nucleus. Such syllables are universally marked and avoided (Carlisle, 2001; Hyman, 2008). Crosslinguistic studies converge on these findings in which children rank markedness constraints against such structures that pose acquisition difficulties. In the Table 4d data, we summarize a few cases of syllable-based phonotactics that drive the emergence of phonological processes from adult input forms given in 4c below.

Table 4c: Adult input data

sn	Input	Output	English Gloss	Input	Output	English Gloss
1	/mtoto/	[m̩.to.to]	a baby	/mwana/	[mwa.na]	a child
2	/aca/	[a.ca]	let go	/mwizi/	[mwi.zi	a thief
3	/nne/	[n̩.ne]	four	/huju/	[hu.ju]	this one
4	/safi/	[sa.fi]	clean	/m ɟi/	[m̩.ɟi]	a town
5	/salimia/	[sa.li.mia]	greet	/sipageti/	[si.pa.ke.ti]	spaghet
6	/ɲuᵐba/	[ɲuᵐba]	a house	/ɲⁿɟi/	[ɟ.ⁿɟi]	country
7	/huju/	[hu.ju]	this one	/kalamu/	[ka.la.mu]	writing pen

Table 4d: Emergent syllable-based phonological processes

sn	Data 1	Data 2	Process	Motivation
1	/mtoto/-[to.to]	/mwana/-[ma.na]	Deletion	Avoid syllabic nasals and consonant clusters
2	/aca/ - [ja.ca]	/mwizi/-[mu.wi.si]	Epenthesis	Provide onset, avoid consonant cluster
3	safi/ - [fa.fi]	/huju/ - [ju.ju]	Consonant harmony	Compensate for an unaquired syllable type
4	/nne/ - [ne.ne]	/m̩ɟi/-[ci.ci]	Assimilation	Avoid syllabic nasals, compensate for lost [m]
5	/salimia/[sa.mi.lia]	/sipageti/ [pa.si.ke.ti]	Metathesis	Articulate easy onsets first before the difficult
6	/ɲuᵐba/-[ju.pa]	/nne/ - [i.ne]	Denasalisation & nasal substitution	Avoid syllabic nasals or nasals
7	/huju/ - [ju:]	/kalamu/-[ka:.mu]	Compensatory (V) lengthening	Satisfy Faith- MAX (μ) and avoid fricative /h/

The child output when compared with the input from the adults show seven main processes at the syllabic level. The most pervasive are phoneme deletion and epenthesis. Deletion mainly targets onset clusters that are reduced to one consonant and deletion of syllabic consonants that subjects were unable to acquire by the time they were five years old. Similarly, epenthesis targets onset clusters in which vowels are inserted to break the cluster or consonants inserted to provide an onset for onsetless syllables. Other processes involve consonant harmony that compensates for un-acquired and difficult fricative sounds and assimilation that also compensates for un-acquired or difficult fricatives and avoidance of syllabic nasals.

Assimilation may be preceded by substitution in which the child initially produces [a.pi] then [pa.pi] before [fa.fi] from input /safi/. Metathesis occurs when the child confronts syllables beginning with fricative sounds, they simply move to the next syllable before reverting back to the fricative onset syllable. Producing a series of nasals is a challenge to children, yet articulating a syllabic nasal is even more challenging, therefore, they denasalize by avoiding the nasal completely or producing only one of them. Finally, the data show that faithfulness to underlying moraic count in vowels may force the subjects to avoid producing a syllable with a fricative onset sound but lengthen the next vowel in compensation for the lost vowel.

Kiswahili syllable structure can be divided into four basic types; the universal CV (Consonant Vowel), onsetless V (Vowel alone), CCV (typically Consonant Glide Vowel) and the N (syllabic nasal) structure. This structure is prevalent among eastern Bantu languages including Kiswahili (Maddieson & Ladefoged, 1993; Nandelenga, 2015). Syllabic consonants are restricted to nasals as heads (nucleus) of the syllable. (Note that unassimilated Arabic loanwords have a foreign syllable structure not included here). The two subjects consistently produced the CV syllable ahead of the rest regardless of the input. This syllable type has been described as the most unmarked cross-linguistically because all languages have a CV structure and some have it as the only type (Blevins, 2004; Levelt & de Vijver, 2004; Goldsmith, 2011).

In OT analysis, the preference for the CV syllable type is due to markedness constraints ONSET, *CODA, *COMPLEX$_{\text{ONSET}}$, and *PEAK-C dominating faithfulness constraints; MAX-IO, DEP-IO and IDENT-IO. These are the universal constraints that will be used in the analysis by ranking them in a Kiswahili specific constraint hierarchy. Initially, subjects rank these markedness constraints above the faithfulness constraints which engender the observed phonological processes. The constraint ranking will therefore be; ONSET, *CODA, *COMP$_{\text{ONSET}}$, *PEAK-C ≫ MAX-IO, DEP-IO. First, we examine deletion in the input /mtoto/ → [to.to].

Tableau 6: /mtoto/ → [to.to] 'a baby'

/mtoto/	ONSET	*CODA	*COMP$_{\text{ONS}}$	*PEAK-C	MAX-IO	DEP-IO
a☞[to.to]					*	
b[mu.to.to]						*
c.[m̩.to.to]				*!		
d.[mto.to]			*!			
e. [o.to]	*!				**	

Two markedness constraint drive the deletion of the bilabial nasal stop [m], these are *COMP$_{\text{ONSET}}$ and *PEAK-C which ban complex onset cluster [mtV] and the syllabic consonant [m̩]. These two constraints must dominate the anti-deletion constraint; MAX-IO. Other constraints are included to rule out possible candidates based on OT's principle of 'Freedom of Analysis' and Richness of the Base' (that any candidate is possibly optimal). [mo.to] 'fire' as a possible candidate would actually tie with the optimal candidate based on this ranking. However, this is an existing lexeme in the language with independent meaning. The universal undominated constraint against semantic neutralization; CONTRAST, would rule it out completely.

Similarly, the data show that given /mwana/ the subjects produced [ma.na] with deletion of the voiced labio-velar glide. Same constraints are invoked with the addition of a markedness constraint that bans labio-velar [w] because it is acquired after the nasal stop [m]. The relevant constraint is *LABIO$_{\text{VELAR}}$ which is ranked above all faithfulness constraints as follows; ONSET, *CODA, *COMP$_{\text{ONSET}}$, *LABIO$_{\text{VELAR}}$ ≫ MAX-IO, DEP-IO. The interaction of these constraints is shown in Tableau 7 in which deletion is the optimal solution to avoid consonant cluster [mwV].

Tableau 7: /mwana/ → [ma.na] 'a child'

/mwana/	ONSET	*CODA	*COMP$_{\text{ONSET}}$	*LABIO-VELAR	MAX-IO	DEP-IO
a☞[ma.na]					*	
b. [mu.wa.na]				*!		*
c. [mwa.na]			*!	*		
d.[wa.na]				*	*	
e. [a.na]	*!				*	
f. [man]		*!			*	

Observe that the onset consonant [w] is deleted instead of [m] because the latter is acquired quite early while the former is acquired late as shown by the markedness constraint *LABIO$_{\text{VELAR}}$ against its presence at this stage. Similarly, ONSET and *CODA ensures that only CV syllables emerge in the child's transitional grammars.

In the following analysis, we examine epenthesis and report that similarly, markedness constraints outrank the faithfulness constraints leading to insertion of segments. In /aca/ → [ja.ca] 'let go/abandon' epenthesis of a consonant is meant to provide an onset due to the demands of ONSET. Similar ranking is adopted but without the

*COMPLEX$_{ONSET}$ which is relevant in the next Tableau 9 but instead include *DORSAL to rule out candidate (e).

Tableau 8: /aca/ → [ja.ca] 'let go/abandon'

/aca/	ONSET	*CODA	*DORSAL	MAX-IO	DEP-IO
a☞[ja.ca]					*
b. [a.ca]	*!				*
c. [ac]		*!		*	
d.[ja.ja.ca]					**!*
e. [ka.ca]			*!		

Candidate (a) that has an epenthetic segment is declared optimal based on comparative evaluation of harmony. By providing an onset, the candidate violates DEP-IO, but this is a low-ranking constraint with little effect because the competing candidate incur fatal violation marks in not satisfying the undominated constraints.

The same result obtains when we analyze /mwizi/ → [mu.wi.si] 'a thief' in which epenthesis is tolerated to ensure consonant clusters are repaired during the input-output mapping. Similar ranking is adopted, however, we need the anti-complex onset constraint *COMPLEX$_{ONSET}$ to induce epenthesis and also, a constraint that forbids obstruent voicing *OBS$_{VOI}$, to change the voiced alveolar fricative/z/ into voiceless /s/. Consequently, an IDENT-IO constraint is required to penalize any change in feature (voice, vowel) specification in the output. The result is as shown in Tableau 9.

Tableau 9: /mwizi/ → [mu.wi.si] 'a thief'

/mwizi/	ONSET	*CODA	*OBS$_{VOI}$	COMPL ONSET	MAX-IO	DEP-IO	IDENT-IO
a ☞[mu.wi.si]						*	*
b. [mwi.zi]			*!	*			
c. [mi.si]					*		*!
d. [u.wi.si]	*!				*	*	*
e.[mu.wis]		*!			*	*	*

In the tableau, *COMPLEX$_{ONSET}$ triggers the violation of DEP-IO hence epenthesis is possible to repair the onset cluster while devoicing of [z] is driven by the top ranked *OBS$_{VOI}$ that results in the violation of the low ranked IDENT-IO$_{VOI}$. The optimal candidate is one that has inserted a vowel to break the consonant cluster. In the next analysis, we examine consonant harmony in child phonology.

As a phonological process, consonant harmony is very similar to assimilation in that neighbouring sounds or syllables are modified to look similar in some feature specification. Often, sounds come to share place or manner of articulation and voice features. In this respect, consonants harmonize for certain features. The markedness constraint AGREE [MANNER, PLACE, VOICE] among others, must dominate some faithfulness constraint; IDENT [MANNER, PLACE, VOICE] for this type of harmony to take place (Walker, 2012). In our data, we consider /safi/ 'clean' realized as [fa.fi] and /huju/ 'this person' realized as [ju.ju]. Each is examined in turn in tableaux 10 and 11 respectively. Table 10 shows place of articulation type of vowel harmony.

Tableau 10: /safi/ → [fa.fi] 'clean' (adj)

/safi/	ONSET	*CODA	AGREE-[PLACE]	MAX-IO	DEP-IO	IDENT-IO$_{PLACE}$
a. ☞[fa.fi]						*
b. [sa.fi]			*!			
c. [a.fi]	*!			*		
d. [saf]		*!		*		
e. [pi]				*!*		*

In the data, the harmonizing feature is responsible for changing [s] which is difficult to articulate to [f] that is acquired earlier. Remember that both sounds share all phonological features except the place feature; [s] is [+CORONAL, -LABIAL] while [f] is [-CORONAL, +LABIAL]. Note also that there is no limit to the number of competing candidates except that more constraints will have to be posited to ensure the attested form is the true optimal candidate in the language.

Another example of consonant harmony is given in tableau 11. The constraint against fricatives is responsible for the harmonizing feature that changes [h] to [j]. This is *OBS$_{CONT}$, which must dominate the input-output correspondence constraints (IDENT$_{OBS\text{-}CONT}$). However, in consonant harmony analysis, the AGREE [PLACE,MANNER & VOICE] is sufficient to initiate regressive consonant harmony from [j] to [h]. Because [h] does not share place-manner of articulation features besides the phonation (voicing) feature with the [j], there is need for the three features to be specified in the harmonizing process. We simplify the agreement to the standard and general AGREE[F] (see Walker, 2012) due to limitation of space in the tableau cells.

Tableau 11: /huju/ → [ju.ju] 'this person'

/huju/	ONSET	*CODA	AGREE-[F]	MAX-IO	IDENT-IO
a. ☞[ju.ju]					***
b. [hu.ju]			*!**		
c. [u.ju]	*!			*	
d. [juj]		*!		*	***
e. [ju]				*!*	

The optimal candidate is candidate (a) in which the place features; palatal and therefore [+CORONAL], manner features; [+SONORANT] and the laryngeal features; [+VOICE] are duly shared by the two consonants. The non-coronal, non-sonorant and voiceless glottal fricative takes on the positive features of the palatal glide [j] in total regressive consonant harmony, thus realized as [j].

Finally, an examination of denasalisation which involves substitution of nasals with non-nasal sounds for the same reason that nasals are marked while oral sounds are the unmarked, expected and normal (de Lacy, 2006; Flack, 2007). We analyze the mapping of /ɲu^{m}ba/ 'a house' on to [ju.pa]. It is proposed that markedness constraints against non-labial nasals is responsible for substituting palatal nasal stop [ɲ] for the palatal glide [j] and those against complex segments substitute the contour segment [^{m}b] which is a voiced bilabial prenasalized stop and therefore, complex compared to a pure stop. The constraints are *NASAL$_{[-LABIAL]}$ and *COMPLEX$_{SEGMENT}$ (shortened to *NAS$_{[-LABIAL]}$, *COMP$_{SEG}$ respectively). Both of them are top ranking in the constraint hierarchy to initiate the denasalisation process. Conversely, two faithfulness constraints from the identity family of constraints are proposed; IDENT$_{NASAL}$ and IDENT$_{COMP-SEGMENT}$ (simplified as IDENT$_{NAS,}$ IDENT$_{COMPSEG}$) in the tableau. The ranking is; ONSET, *CODA, *NAS-$_{LAB}$, *COMP$_{SEG}$ ≫MAX-IO ≫ IDENT$_{NAS,}$ IDENT$_{COMPSEG,}$ as shown in tableau 12.

Tableau 12: /ɲu^{m}ba/ → [ju.pa] 'a house'

/ɲu^{m}ba/	ONSET	*CODA	*NAS -LABIAL	*COMP$_{SEGMENT}$	MAX-IO	IDENT$_{NASAL}$	IDENT COMPSEG
a ☞[ju.pa]						*	*
b. [ɲu.^{m}ba]			*!	*			
c. [ju.p]		*!					
d. [ju. ^{m}ba]				*!			
e.[u.pa]	*!				*		*

The result indicates that, based on these constraints, the optimal candidate is the one that substitutes all nasals and nasal features with oral consonants. It is possible to merge all the 'IDENTITY' constraints under a general IDENT-IO [F] which penalize any feature disparity between the input and its corresponding output. This will ensure, for example, that outputs such as [ju.ba] which could be declared optimal based on the above ranking, do not do so. It is also possible to rule out such a candidate by simply including a co-indexed feature [VOI] under IDENT–IO alongside underscript [NASAL] as done above in the cell for constraint column six and seven.

A similar case of denasalisation process exhibits the same pattern in which markedness constraints sets in motion the process of denasalisation. Typically, syllabic nasals are replaced by the canonical vocalic segments (the default syllable peaks or nuclei). Furthermore, orality is the unmarked manner of articulation for consonants, nasals are often replaced by oral sounds in child language acquisition (except /m/). Most of the constraints proposed so far are adequate to derive the optimal candidate. However, two new constraints *PEAK-C$_{NASAL}$ and OCP$_{NASAL}$ are included to assess candidate harmony. The former bans syllabic nasals, while the second bans adjacent similar segments (Myers, 2004).

The two constraints are invariably markedness constraints that trigger denasalisation and therefore, must be ranked above all the faithfulness constraints which includes IDENT-IO$_{NASAL}$ and IDENT-IO $_{PEAK-C.}$ It is important to note that ONSET constraint has been demoted to a lower rank as indicated by the optimal [i.ne] which has its first syllable as onsetless, but retain the ranking for *CODA because no coda consonants are permissible. This is at the core of constraint demotion in child language acquisition. Denasalisation which is a special form of phonemic substitution is shown in the following tableaux 13 based on the input-output mapping of /nne/ on to [i.ne]. The constraints ranking proposed are; ONSET *CODA, *PEAK-C$_{NASAL,}$ OCP$_{NASAL}$ ≫MAX-IO ≫ IDENT-IO$_{NASAL,}$ IDENT-IO $_{PEAK-C}$

Tableau 13: /nne/ → [i.ne] 'four'

/nne/	*CODA	*PEAK-C NASAL	OCP NASAL	MAX-IO	ONSET	IDENT$_{NASAL}$	IDENT PEAK-C
a ☞[i.ne]					*	*	*
b. [n̩.ne]		*!					
c. [nne]			*!				
d. [ne]				*!			
e.[in.ne]	*!				*		*

The optimal candidate is (a) which denasalizes by substituting the syllabic nasal with a vowel violates three faithfulness constraints. However, because of strict domination, these violations are of little effect on its harmony. Also, note that candidate (e) could easily have emerged as optimal if we did not have *CODA constraint operative in the phonology of Kiswahili and ranked as undominated. However, it is important to observe that candidate (e) also violates a low-ranking faithfulness constraint; DEP-IO, which is not included due to reasons of space in the tableau, but it must be assumed that it maintains its position in the tableau at this stage in the analysis.

This far the constraints have been sufficient in accounting for the attested phonological process that accompany the acquisition of Kiswahili. Although we have not examined all processes such as metathesis and compensatory lengthening of vowels, they are amenable via recourse to constraint interaction. In metathesis, for example, initial syllables with fricatives or liquids which are acquired late, may be swopped with the following syllables already acquired. This violates faithfulness constraint LINEARITY-IO which must be low ranked similar to other faithfulness constraints. In /salimia/ → [sa.mi.lia] 'greet-applicative' the child avoids the liquid onset [l] and swaps with [m] a sound that is acquired quite early due to the top ranked *LATERAL dominating LINEARIT-IO and IDENT$_{LATERAL}$ which forbids variation in sound sequencing and feature values between inputs and outputs, respectively.

The same argument can be advanced in respect to compensatory lengthening in which one vowel is deleted but the remaining vowel lengthens in compensation. In Moraic phonology, vowels are said to have moras which are auto-segmental in nature to the extent that when a vowel is deleted, the mora remains and attaches to the following vowel which simultaneously lengthens due to mora preservation principle (Davis, 2011). In OT, faithfulness to the mora count is recast into faithfulness constraint (MAX-IO) which forbids deletion of moras even when vowels are deleted. This should dominate a faithfulness constraint; IDENT-IO(V) demanding correspondence between input and output vowels in the mapping process (Becker & Tesser, 2011).

4.0 Results and Discussion

Having analyzed the phonological processes attendant in the acquisition of the Kiswahili phonemic inventory and the syllable structure, the next section discusses the results. The discussion is in light of our study objectives and findings from cross-linguistic acquisition research and the implication for the linguistic theory.

4.1 Phonemic-based Phonological Processes

The results indicate that for every phonological process, there is a markedness constraint responsible for triggering the process. The markedness constraints may be operating alone, but often, they operate in tandem with other markedness constraints that militate against what is considered 'marked' and therefore, difficult to acquire by the developing child. Markedness constraints are consistently ranked above faithfulness constraints for any phonological process to take place (Gnanadesikan, 2004; Hayes, 2004). Phonological processes are basically anti-faithful; they generally change output forms to adhere to some phonological well-formedness (Fikkert, 2007) and therefore, they must be triggered by high ranked markedness constraints.

In the acquisition of the phonemic inventory, voiceless plosives are preferred and will substitute the voiced plosive, fricatives, liquids and nasals. However, the voiced bilabial nasal stop [m] is universally acquire first, in fact ahead of many stops and all other nasals. This has been attributed to the child's habitual sucking of the mother's teats that prepares the labial muscles to handle labial sounds better (Bavin, 2009). However, plosives are generally acquired ahead of nasals, except [m], (Fikkert, 2007; Saxton, 2017). Use of universal constraints is all that is required to account for the developmental stages and the concomitant phonological processes. The demands of ONSET constraints may result in consonant epenthesis to provide an onset or may lead the deletion of offending vowel to ensure onsetful syllables only.

Devoicing of obstruents is a common feature prompted by the constraint *OBS$_{VOI}$ (McCarthy, 2004). This is because the unmarked status of obstruents is voicelessness based on phonetic implementation of phonation; voicing is effortful in non-sonorants (obstruents) and from acoustic cues of voicing (Johnson, 2003). Neutralization may result from all the processes mentioned above, in particular, laryngeal neutralization that accompany devoicing. Fronting converts dorsals into coronals, the unmarked sound type in terms of place of articulation (Lombardi, 2002; de Lacy, 2006).

In lenition, strong phonemes (on the strength scale) are made weak and the preferred output is the coronal palatal [j] which is also the preferred epenthetic segment in most Bantu languages (Hyman, 2008, Nandelenga, 2015) largely because of its phonological phonetic unmarkedness (Kang, 2000; Flack, 2007). Spirantization is a classic case of the U-shaped language development in which one subject (MS2) initially produced voiceless fricative [θ] instead of the voiceless alveolar plosive [t]. The subject had a habit of sticking her tongue between her teeth hence the ease in producing the inter-dental fricative. However, the subject unlearned this sound hence producing [t] instead of [θ] in later stages before being able to fully produce [θ] again. In OT, the child is assumed to keep re-ranking constraints and this may explain the U-shaped language development in first language acquisition (Smith, 2009).

4.2 Syllable-based Phonological Processes

Phonological processes are mainly triggered by the need to adhere to the syllable structure of the language or due to articulatory adjustments or alternations. In OT, the same universal constraints accounting for acquisition of the phonemic inventory and the syllable structure can be used to account for the phonological processes accompanying the acquisition process. A child is faced with many limitations in articulating some sounds. This is the essence of OT constraints being grounded in phonetics (phonetically grounded) or phonetic determinism (Hayes et al; 2004).

Unacceptable onset cluster that is difficult for the subjects is avoided through deletion of one consonant sound or epenthesis of a vowel to break the cluster. *COMP$_{\text{ONSET}}$ sets in motion these two phonological processes. Similarly, ONSET may engender either epenthesis of a consonant to provide an onset or deletion of the offending vowel without an onset because the CV syllable is not only easy to produce but also easy to perceive (Carlisle, 2001; Levelt & de Vijver, 2004). Ease of articulation generally results in assimilation (sounds are made to look similar) reducing articulatory effort because two sounds are produced at the same place or with the same voicing feature.

Articulation of different sounds in terms of place, manner and voicing require more muscular effort and gestural coordination. In consonant harmony and assimilation, sounds share these articulatory parameters and are thus produced with less gestural coordination and, therefore less effort (Levelt, 2011). Production of [ju.ju] from /huju/ is a good example. Denasalisation is also driven by markedness against syllabic nasals or a sequence of nasals due to the high ranking *NASAL and *PEAK-C (only nasals are syllabic in Kiswahili) similar to other eastern Bantu languages spoken in Kenya. This being a typological universal, universal markedness constraints were able to adequately account for processes that denasalize input nasals in the phonetic form.

If the initial sound in a syllable onset is difficult or not yet acquired, the child has multiple options, which are explained through constraint ranking. The child may substitute the sound for another, violating IDENT-IO, delete the sound, violating MAX-IO or invoke metathesis in which the difficult syllable is skipped, the following sound (if less marked) is produced first. Metathesis is a violation of the linear sequence of sounds/syllables. This is a violation of LINEARITY-IO constraints which in this case, had to be low ranking. Phonological processes involve feature changes in the target sounds; therefore, the IDENT-IO family of constraints must be ranked low while the triggering markedness constraints ranked high in the constraint hierarchy to induce the alternations. These findings mirror other studies in which markedness constraints initially outrank the faithfulness constraints and also the former initiates phonological processes (Gnanadesikan, 2004; Fikkert, 2007; Levelt, 2011). The final stage is the acquisition process is eventually attained when markedness constraints are demoted below the faithfulness constraints.

Every phonological process has a trigger markedness constraint demanding change. Markedness theory (de Lacy, 2006), therefore, provides a formal mechanism of accounting for why certain sounds are acquired faster than others and why our physiological limitations may determine which sounds are acquired faster, slowly or never at all. The phonetic grounding of constraints is thus linked to these limitations.

5. Conclusion

Findings from the study indicate that constraints, when ranked appropriately at the different developmental stages, are able to account for the emerging phonological processes in the child's output. Unlike the rule-based Generative Phonology (GP) approach, none of the OT analysis produces non-occurring or non-recurrent phonological processes. Specifically, OT elegantly handles multiple processes triggered by a single constraint (cf. ONSET) such as deletion and epenthesis. In GP this led to rule duplication and ordering paradoxes; for example, whether or not to order vowel deletion rule before consonant epenthesis rule to provide an onset. In OT, phonological processes are driven by the top ranked markedness constraints conflicting with and enforcing violation of low ranked faithfulness constraints. Initially, both subjects ranked markedness constraints above faithfulness constraints. Acquisition towards adult target language is progressively achieved by re-ranking of constraints which involves demotion of markedness constraints over faithfulness constraints. Variation at each stage is accounted for by simple recourse to constraint re-ranking in light of new 'evidence' from the adult input until native-like norm is attained (when the constraint hierarchy is stable with no re-ranking of constraints). Future studies should examine constraint re-ranking in the acquisition of two languages simultaneously for purposes of typological comparison between bilingual and monolingual constraint interaction. Similarly, phonological processes in bilingual acquisition among children acquiring different languages may offer an opportunity to test the concept of Universality Grammar (UG) in child language acquisition through constraint demotion (markedness) and promotion (faithfulness).

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