THE INTERFACE BETWEEN MORPHOLOGY, PHONOLOGY AND SEMANTICS IN STANDARD SWAHILI COMPOUND NOUNS

Michael A. Mashauri[1]

Abstract

This article serves two purposes: firstly, it demonstrates the use of a constraints approach in dealing with certain aspects of Swahili. Secondly it is shown that this approach gives a clearer picture than is usually afforded of the interface of grammatical modules in forming Swahili compound nouns. Specifically this analysis will focus on the interaction between morphology, phonology and semantics in forming compounds, showing how stress, vowel length, and intonation (phonology) interact with morphology (in compounding operation) and with the meaning constraints in forming optimal compound nouns. It is argued here that optimality theory (OT) serves best in accounting for the interaction phenomena between more than two modules. Further, these considerations heuristically suggest that the constraints approach, based upon OT, might be productively employed by researchers for investigation in other fields of study across the humanities such as sociolinguistics and cultural studies involving complex communication and preservation of meaning content.

Key words: *interface, noun compounds, linguistic constraints, grammar*

Introduction

The Swahili language is in itself a cultural heritage as well as a medium of communication. As such it has been dealt with by many professionals including linguists, most of whom have used rule-based approaches to discussing and analysing its characteristic patterns. To my knowledge, there are very few works that have extensively employed a constraints approach in dealing Swahili language aspects. Therefore, the constraints approach (based upon optimality theory) is used here to illuminate standard Swahili compound nouns. It will be shown that when two or more

[1] Department of Kiswahili Language and Linguistics, Institute of Kiswahili Studies, University of Dar es Salaam, Tanzania.

words are combined via morphological operation to form a compound noun, the stress, the vowel length, the intonation and meaning result in some modifications for the form produced; and this allows for optimal meaning to Swahili speakers. Modules of grammar in any language work together in various ways to form grammatical word structures which are used by a speech community in daily interactions. This fact led some linguists to define the concept 'grammar' as including concepts of all modules. Kihore, et al. (1999) define a grammar as the science of language structure together with its rules and principles that govern the use of that language which normally is accepted by its users. Taasisi ya Uchunguzi wa Kiswahili (1990) also says that grammar is a study which involves all linguistic modules which are phonology, morphology, syntax and semantics. These definitions match the view provided by Farmer (1985: 25, 33) who argues that grammar is like a system which has a connection of various distinct components that work together. He argues that grammar is a system which has different minor principles and rules functioning as a huge system of rules and principles (i.e. a grammar). These minor systems are distinguished as morphology, phonology, syntax and semantics. Ackema and Neeleman (2004: 1-3) are of the opinion that word formation does not depend on morphology exclusively, but morphology works together through interfacing with other modules in forming words. Thus, a word has to meet all the requirements set forth by the constraints of these modules in order for it to be optimal in its use within that specific language by a specific speech community.

This approach illuminates how words are characteristically accepted for use when they meet all their grammatical requirements in a specific language. In other words, what it means for a word to be considered grammatical and thus acceptable by a speech community, is that it meets all the phonological, morphological, syntactic and semantic requirements of that community's language. The strength of the constraints approach is that it illuminates how these modules need to work together in order to produce the word forms that are found acceptable for a speech community's use. This general principal can be seen as holding true, in particular, with the formation of compound nouns in Swahili grammar. This paper deals with the interaction of only three modules for the purpose of demonstrating the use of optimality theory in analysing the phenomenon of this linguistic interaction.

The study of the interface of various grammatical modules to form words in human languages began in the 1990s (Martinet 1973 [1965]: 16). Since that era there have been many linguists who have dealt with the same kind of interactive phenomena in various linguistic aspects. For example, Li (2005: 1-7) and Inkelas (2011: 68-102) deal with the interface between morphology and syntax. Elordieta (2008: 209-289), Selkirk (2011: 435), and

Downing (2013: 26-38) deal with the interface of phonology and syntax. And Lechner (2015: 1204) deals with syntax and semantics, to mention a few. Most of these works use derivational theories and analyse the interaction of only two grammatical modules at a time.

In this work, optimality theory (henceforth OT) has proven to be a good approach in dealing with the interaction of various linguistic aspects in forming compounds. Through arrangements of constraints, the interaction between more than two modules can be shown and analysed at one stage of analysis. This parallel kind of analysis by OT also suggests that when forming a compound noun, all constraints (which are needed to set requirements for compounds) work together at one stage to produce a complete and optimal form ready for use by the speech community. It is hope that the use of OT in this paper can satisfactorily account for the formation of acceptable compound nouns in standard Swahili.

Literature review

Compound nouns refer to the nouns formed by combining two or more words to represent one concept (a single unit of meaning). For example, mwana (son) + mazingira (environment) = mwanamazingira (environmentalist). Linguists have discussed the interface of compound nouns in many languages. Some of these linguists have pointed out simply that modules other than morphology also play a part in forming compound nouns, without pursuing any analysis of that discovery. For example, Polome (1967: 80-82) ascertains that when forming Swahili compound nouns, stress shifts to the penultimate syllable of the second word; but Polome never says anything else concerning this pattern. Another linguist is Gichuru (2010) who argues that morphological, phonological and syntactic rules work together in forming compound nouns in Swahili. But as in Polome's work, Gichuru's analysis does not demonstrate how these modules work together in forming compound nouns in Swahili. Yet another seminal work on Swahili compound nouns is by Lusekelo (2014). He also gives a descriptive analysis of compound noun structures and their categories.

The work of these linguists sheds light on different kinds and structures of Swahili compounds. Apart from these linguists, others including as Ashton (1944), Mdee (1988), and Matei (2008), have just listed Swahili compounds without showing any theoretical or deep descriptive analysis as Gichuru and Lusekelo had done. Moreover, none of these works dealing with compound nouns has used the constraints approach. Nevertheless these works remain important to consider since they shed light on other aspects of

structure and categories of Swahili compounds that are not dealt with in this paper.

A glance at optimality theory (OT)

Optimality theory (OT) uses universal constraints that set requirements for evaluating an optimal form from the endless list of output forms which are generated in a specific language. OT has three major components as its basic principles. The first component is Constraints (CONS) which sets forth criteria used to determine an optimal form in a specific grammar (Prince and Smolensky 1993: 3). These constraints are arranged hierarchically according to their strength in evaluating the grammaticality of the output form. They are also violable depending on the needs of the grammar in producing optimal forms. Constraints are of two kinds: faithfulness and markedness. Faithfulness constraints are those which require correspondence between the input and the output produced, while markedness constraints favour some modifications of the input to produce an optimal output. Faithfulness Constraints constitute a family of three constraints: MAX-IO (maximum input-output correspondence), DEP (dependant on the input) and the IDENT (F) (featural identical).

The second component is GEN (generator). This is the component which is responsible for generating unlimited output forms from the input. The theory assumes that all generated output forms are in conflict with each other to win the competition for being evaluated as optimal in a given grammar. The third component is EVA (evaluation) which evaluates the output forms generated by GEN against all criteria set forth by CONS at one step (in parallel). Output forms which violate many or strong constraints lose in the competition; and the one form that satisfies strong constraints or violates the fewest weak constraints carries off the competition. An output can violate one or two constraints and lose in the competition if it violates strong constraints. The output which wins in the competition is evaluated as optimal in a given grammar.

A further four pillars of OT worth mentioning because they play a central role in analysing linguistic aspects are: universality, violability, arrangement and parallelism. Firstly, as mentioned earlier, constraints are *universal* since OT has focused on building a universal grammar; the theory's first component is a set of universal constraints. Secondly, these constraints can be *violated* by the output in favour of grammaticality, although the violability that results must be minimal. Maximum violation leads to ungrammaticality of the output (Massamba 2011). Thirdly, after developing constraints, they are hierarchically *arranged* according to their strength in evaluating an optimal form. In the tableaux, strong constraints are arranged

on the leftmost side and the weak constraints on the rightmost. The fourth pillar, *parallelism*, states that evaluation of an optimal form is done against the whole set of constraints at one step. It is key to note that satisfaction of all constraints is met simultaneously, as it were, in one step (McCarthy 2000: 3, McCarthy and Prince 1993: 6, and 1994: 3).

Data analysis under OT is carried out by using tableaux which have columns of constraints on top, and rows of output forms on the left side moving downward. The tableaux have boxes in which various symbols[2] are placed against every constraint. After collection of data has been completed, the first step before analysing the data is to formulate constraints and arrange them according to their strength.

Data presentation and analysis

Data analysis under OT begins with formulation and arrangement of constraints. Constraints which have been formulated in this section are divided into three groups: morphological, phonological, and semantic constraints.

Morphological constraints.

Compounding as a method of word formation is a morphological operation which has the following constraints:

Faithfulness constraints

1. MAX-IO (Affix): Affixes attached to the output must have correspondence to the input. It forbids dropping affixes from the input. For instance, mwana 'son'+**m**ke 'female' => *mwanake 'woman'. Affix *m-* has been dropped from the second word, so it has violated this constraint.
2. DEP (Affix): Affixes on the output should depend on the affixes of the input forms. It forbids adding affixes which are not found in the input forms. For instance, paza 'shout'+ sauti 'voice' => kipazasauti 'microphone'. The affix *ki-* has been added to form an acceptable compound but it has violated this constraint.
3. IDENT (Affix): Functions of affixes attached to the output should be identical to those of the input. For instance, if an affix attached to the

[2] Asterisk *(**) means violations of (weak) constraints
Exclamation (!) means violations of strong constraints
An asterisk and an exclamation (!) means violations of strongest constraints
Hand (☞) means optimal form, >> means greater than

input shows noun class, singular or plural form, an affix that is attached to the output must also show the same.

4. Express{Num[ber]}. It requires that compound nouns must show the singular or plural affixes. It is violated by uncountable compounds, those with null singular and plural affixes and lexicalized compound nouns.

Markedness constraints

1. Compounding constraint $\{\omega\Sigma\omega\Sigma^{3}{}_{n}\}$. It requires that combination of two or more words must result to a single unit of meaning as one morphological word. For example, Bata 'duck'+mzinga 'canon' => batamzinga 'turkey'; this resulting word is considered as one word although it has two roots as it gives one unit of meaning. This CONS can be violated by lexicalized compound noun like 'uti wa mgongo' 'spinal cord' which has three separate words although they give a single unit of meaning.

2. $W[ord]_1\{Num[ber]\}_{Comp}$: It requires that singular or plural affixes must be attached to the first word of the compound. For instance, mnyama 'animal'+pori 'forest' => **m**nyamapori 'wild animal' to be **wa**nyamapori 'wild animals' and not *mnyama**ma**pori.

3. $W[ord]_1\{Ncl.\}_{comp}$: It requires that noun class affix be attached to the first word of the compound. It has similar examples as in constraint 2 above.

Phonological constraints

Phonological aspects that have been attested as playing a part in forming compound nouns in standard Swahili are stress, vowel length, and intonation. The following are constraints for these aspects in forming compound nouns in Swahili:

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[3] [ ] phonetic representation
ω phonological word
ϕ intonational phrase
) right edge
(left edge
Σ means morphological merging
{ } means morphological boundaries
>> means 'stronger than'

Faithfulness constraints

1. MAX-IO: It requires no deletion of segments and suprasegments from the input. It is the family of three constraints. MAX-IO(Vlength) which needs correspondence of vowel length between the input and the output; MAX-IO(stress) which requires correspondence of the input stress and output stress and MAX-IO(segment) that needs correspondence between sound segments of the input form and sound segments of the output form. For example, a compound [batam'zi:ŋga] 'turkey' from ['ba:ta] 'duck'+[m'zi:ŋga] has violated MAX-IO (Vlength) and MAX-IO(stress) by dropping primary stress from the first word 'bata' and reduce the vowel length on the vowel of the stress bearing syllable *ba* of ['ba:ta].
2. DEP: Requires that segments and suprasegments of the output depend on those of the input forms. It forbids insertion of new segment or suprasegment. So, there are DEP(segments), DEP(stress) and DEP(Vlenght). So, our example, [batam'zi:ŋga] 'turkey' from ['ba:ta] 'duck'+[m'zi:ŋga] has not violated this constraint family since it has not inserted any segment.
3. IDENT: Requires that features of segments and suprasegments in the output be identical to those of the input forms. There is IDENT(stress), IDENT(Vlength) and IDENT(segment Features). Our example [batam'zi:ŋga] 'turkey' from ['ba:ta] 'duck'+[m'zi:ŋga] has violated this constraint. The first word has dropped the primary stress and remain with the secondary stress and the vowel length of the stress bearing syllable is shortened, so these features are not identical to those of the input word ['ba:ta].

Markedness constraints

1. $\text{Stress}_1\{W_{\#}\sigma_{\#}^{-1}\}_{\text{comp.}}$: This constraint requires that primary stress be realized on the penultimate syllable of the final word of the compound noun. It is similar to DE-ACCENT-N_1 formulated by Alderete (1999: 92) in Japanese compounds; but the difference lies in the fact that Swahili has compounds which are formed by more than two words, so the primary stress is dropped from all words except to the final word (not the first word only). For example, ['ma:li] 'resource/wealth'+[a'si:li] 'natural' becomes [malia'si:li] 'natural resources' and not *[ma'li:asili].
2. Stress_1^1(Comp.): Requires that any compound must have one primary stress. For example, [malia'si:li] and not *[ma'li:a'si:li].

3. Vlength(W[ord]$_{\#}\sigma_{\#}^{-1}$)$_{comp}$.: A vowel of the penultimate syllable of the final word is pronounced as a long vowel. It has been attested that the vowel of the syllable that bear primary stress in Swahili compounds is lengthened as compared to others in the same word during pronunciation. For instance, ['pi:ma] 'measure'+['ma:ɟi] 'water' becomes [pima'ma:ɟi] 'water/spirit level' and not *[pima'maɟi].

4. *Vlength(W[ord]$_1\sigma_{\#}^{-1}\Sigma$W[ord]$_{n\#}\sigma_{\#}^{-1}$)$_{comp}$.: It forbids a compound noun to have long vowel on the penultimate syllables of all words that form a compound noun; for instance, *[pi:ma'ma:ɟi]

5. Align(W,R;ω,R)$_{comp}$.: The right edge of a morphological boundary must be coincided with the right edge of the phonological boundary of a compound and Align(W,L;ω,L)$_{comp.}$ requires that the left edge of the morphological boundary must be coincided with the left edge of the phonological boundary of a compound. For example,

   Pembe 'angle'+kali 'acute' => pembekali 'acute angle'

   {['pɛ:mbɛka:li]} => {[pɛmbɛ 'ka:li]}

   ({[pɛmbɛ'ka:li]})ω and not *({[pɛmbɛ}'ka:li])ω or *{[pɛmbɛ]['ka:li]}¿

   or *([{pɛmbɛ}{'ka:li}])ω

This example shows that a compound is pronounced as one word and considered morphologically as a single unit of meaning. Its alignments enclose all phonological and morphological features of the word in a single word domain as other words.

6. Erase)φ($_{\{comp\}}$: It requires that phonological phrase boundaries between words that form a compound noun must be erased for a compound to be pronounceable. Phonologically, when two or more words are arranged together there is a phonological-phrase boundary between them before an intonational-phrase boundary (Truckenbrodt 1995: 20-22). Therefore, in the formation of compounds these phonological-phrase boundaries have to be erased. For example,

   kata 'cut'+mbuga 'garden' => katambuga 'local sandles'

   (({['ka:ta]})ω)φΣ(({['mbu:ga]})ω)φ => ({[kata'mbu:ga]})ω

   *(({[kata)φ('mbu:ga]})ω

Semantic constraints

These are comprised of three constraints (CONS) under consideration in regard to compound noun formation in this analysis. These are

COMP[OUND]^{1}(M[eaning]^{1}), W_1(Sem[emantic]Head) and INTE[RPRETABILITY].

1. COMP[OUND]^{1}(M[eaning]^{1}): This CONS requires that a compound noun must express one meaning (make a single unit of meaning). Combination of the semantic features of two or more form must result into a single unit of meaning.
2. W_1(Sem[antic]Head)$_{comp}$: This CONS requires that the first word (among the words that form) be the semantic head of the compound noun. It contributes large portion of meaning of the compound.
3. INTE[RPRETABILITY]: This CONS needs a compound to be interpretable according to the input meaning which is acceptable in speech community. Some of the compound nouns are uninterpretable although their forms are grammatical. For example, maji 'water' + kuku 'hen' => *majikuku* (uninterpretable).

Constraints arrangement

The following is the arrangement of the constraints formulated according to their strength

$\{\omega\Sigma\omega\Sigma_n\}$>>Erase)φ($_{\{comp\}}$.>>Stress$_1$^{1}(Comp.)>>Stress$_1${$W_{\#}\sigma_{\#}^{-1}$}$_{comp}$>>Vlength ($W_{\#}\sigma_{\#}^{-1}$)$_{comp}$>> *Vlength($W_1\sigma_{\#}^{-1}\Sigma W_{n\#}\sigma_{\#}^{-1}$)$_{comp}$ >>W_1(SemHead)$_{comp}$ >>INTE >>COMP^{1}(M^{1})>>W_1{Ncl.}$_{comp}$>>

Express{Affix$_{Num}$}>>
Word$_1${Affix$_{Num}$}$_{Comp}$>>Align(W,R;ω,R)$_{comp}$>>Align(W,L;ω,L)$_{comp}$ >>MAX-IO (Affix)>>DEP (Affix)>> IDENT (Affix)>>MAX-IO>> DEP>> IDENT(F)

This arrangement has not been done arbitrarily. Compounding constraint is the first in the arrangement since it is the strongest in forming compounds. Any form violating this constraint is not considered as a compound noun since two or more words must be merged to form a new word that make a single unit of meaning. Then it is followed by the constraint which requires erasing phonological-phrase boundaries between the two or three words that form a compound. Then the form has to be evaluated by stress placement and vowel lengthening constraints, respectively, for a compound to be pronounceable.

Other strong constraints which follow are those which set forth semantic criteria whereby the output is required to have the meaning which is largely expressed by the first word of the compound, the meaning to be interpretable according to the speakers' intentions and that interpretation must

constitute a single unit of meaning. This is followed by the constraint that needs a compound noun to be assigned in a specific noun class. Noun class assignment constraint precedes the requirement of affixes for numbers which need to be expressed by the compound. Then, these constraints are followed by alignment constraints that require a compound to be enclosed in its own domain. The faithfulness constraints MAX-IO (Affix), DEP (Affix), IDENT (Affix), MAX-IO, DEP, IDENT (F) are weak in the production of compounds in standard Swahili. Therefore, they are arranged on the rightmost side in the hierarchy respectively. Despite this kind of constraints arrangement, it does not mean that there are derivational stages in the evaluation process. The arrangement is simply for constraints' strength factor in evaluating the output form since satisfaction of these constraints' requirements considers the strength and weakness of the constraints; hence they have to be hierarchically arranged according to their strength.

Constraints conjunction

Conjoining constraints are needed in analysing interface in Swahili compound nouns. Conjoined constraints refer to constraints which combine two or more constraints that work together as one constraint (Zamma and Kikuchi 2015: 44). Ito and Mester (2003: 23) state that:

> Let C_1, C_2 be constraints and δ be a (phonological or morphological) domain (segment, syllable, foot, prosodic word,…; root, stem, morphological word, …). Local Conjunction is an operation "&" mapping the triplet (C_1, C_2, δ) into the locally conjoined constraint donated by C_1 & C_2 (equivalently, [δ]), the local conjunction of C_1 and C_2.

Conjoined constraints together with constraints arrangement help to overtly account for the way interface takes place in the formation of compound nouns. Apart from working together at a one step in forming compounds, some constraints tend to intertwine with one another to set some requirements for evaluating an optimal form. They may be of the same domain or different domains. This suggests that, OT can show the interface of grammatical aspects through constraints arrangements and/or through constraints conjoining. The following is the arrangement of conjoined constraints.

$\{\omega\Sigma\omega\Sigma_n\}\&_\delta Erase)\varphi(_{\{comp\}}\&_\delta COMP^1(M^1)>>Stress_1{}^1(Comp.)>>Stress_1\{W_\#\sigma_\#{}^{-1}\}_{comp}$

$\&_\delta Vlength(W_\#\sigma_\#{}^{-1})_{comp}>>*Vlength(W_1\sigma_\#{}^{-1}\Sigma W_{n\#}\sigma_\#{}^{-1})_{comp}>>W_1(SemHead)_{comp}\&_\delta INTE>>$

Express{$Affix_{Num/Ncl}$}>>W_1{Ncl.}$_{comp}$&$_{\delta}W_1${$Affix_{Num}$}$_{Comp}$>>Align(W,R;ω,R)$_{comp}$& $_{\delta}$Align(W,L;ω,L)$_{comp}$ >>FAITH{Mor}>>FAITH[Pho]

{ωΣωΣ$_n$}&$_{\delta}$Erase)φ($_{\{comp\}}$&$_{\delta}$COMP^1(M^1) have been combined as they share results of their requirements. This is because for a combination of two or more words to be considered a single unit of meaning, there has to be no phonological boundary between them and they must be morphologically combined as one word. Thus, the moment two or three words are compounded to form a compound noun, Erase)φ($_{\{comp\}}$ erases phonological-phrase boundaries between them on the spot and the meanings are combined to create one concept. Moreover, stress placement constraints on the compound work more closely with vowel length constraint. A syllable which bears primary stress in Swahili compound nouns has a long vowel. This is why Stress$_1${$W_{\#}\sigma_{\#}^{-1}$}$_{comp}$ and Vlength($W_{\#}\sigma_{\#}^{-1}$)$_{comp}$. Constraints are conjoined to form the conjoined constraint Stress$_1${$W_{\#}\sigma_{\#}^{-1}$}$_{comp}$&$_{\delta}$Vlength($W_{\#}\sigma_{\#}^{-1}$)$_{comp}$. As is the case for many compounds in Swahili, W_1(SemHead)$_{comp}$&$_{\delta}$INTE are conjoined because the interpretability of the compounds depends upon the requirement that the meaning of the compound, to a large extent, must be expressed by the first word of the compound. Moreover, W_1{Ncl.}$_{comp}$ and W_1{$Affix_{Num}$}$_{Comp}$ are conjoined because in Swahili the noun class affix marks numbers as well, except for uncountable nouns and those which have null affixes for numbers. So this constraint is ranked lower in the constraint hierarchy in the analysis of these uncountable compound nouns.

Furthermore, Align(W,R;ω,R)$_{comp}$ and Align(W,L;ω,L)$_{comp}$ are conjoined to enclose a compound on both sides (left and right), as a complete word with its interpretation, in its own domain. Morphological faithfulness constraints MAX-IO(Affix), DEP (Affix), and IDENT(Affix) are combined into a faithfulness constraint family named FAITH(Mor), and phonological faithfulness MAX-IO, DEP and IDENT(F) comprise a family named FAITH(Phon) to shorten the tableau and are ranked lower. When analysing data, the violated members of these families have been given an explanation.

Data analysis

Output candidates which are generated under GEN are infinite. In this analysis only five representations are taken as examples. As pointed out earlier, the rows on the left side towards downward contain output forms, and columns on the top show constraints according to their arrangements.

kuku ‘chicken’+ maji ‘water’	=>	kukumaji ‘moorhen/water hen’
({['ku:ku]}ω)Σ({['ma:ɟi]}ω)	=>	({[kuku'ma:ɟi]}ω)

CONSTRAINTS:

$\{\omega\Sigma\omega\Sigma_n\}\&_\delta$Erase)φ($_{\{comp\}}\&_\delta$COMP^1(M^1)>>Stress$_1{}^1$(Comp.)>>Stress$_1\{W_{\#}\sigma_{\#}{}^{-1}\}_{comp}$

$\&_\delta$ Vlength$(W_{\#}\sigma_{\#}{}^{-1})_{comp}$>>*Vlength$(W_1\sigma_{\#}{}^{-1}\Sigma W_{n\#}\sigma_{\#}{}^{-1})_{comp}$>>$W_1$(SemHead)$_{comp}\&_\delta$INTE>>

Align(W,R;ω,R)$_{comp}\&_\delta$Align(W,L;ω,L)$_{comp}$>>FAITH{Mor}>>FAITH[Pho]>> Express{Affix$_{Num/Ncl}$}>>$W_1\{Ncl.\}_{comp}\&_\delta W_1\{Affix_{Num}\}_{Comp}$

Tableau 1: "Kukumaji"

	Set of Constraints									
Inputs ({['ku:ku]}ω), ({['ma:ɟi]}ω) Cat: N; Meaning: moorhen/water hen	**{ωΣωΣ$_n$}&$_\delta$Erase)φ$_{(comp)}$&$_\delta$ COMP^1(M^1)**	**Stress$_1{}^1$(Comp.)**	**Stress$_1\{W_{\#}\sigma_{\#}{}^1\}_{comp}$ &$_\delta$Vlength$(W_{\#}\sigma_{\#}{}^{-1})_{comp}$**	***Vlength$(W_1\sigma_{\#}{}^{-1}\Sigma W_{n\#}\sigma_{\#}{}^{-1})_{comp}$**	**W$_1$(SemHead)$_{comp}\&_\delta$INTE**	**Align(W,R;ω,R)$_{comp}$ &$_\delta$Align(W,L;ω,L)$_{comp}$**	**FAITH{Mor}**	**FAITH[Pho]**	**Express{Affix$_{Num/Ncl}$}**	**W$_1${[Ncl.}$_{comp}\&_\delta W_1\{Affix_{Num}\}_{Comp}$**
a.({[ku:ku'ma:ɟi]}ω)				**				*	*	*
b. ({['ku:ku)('ma:ɟi]}ω)	*!									
c. ({[kukumaɟi]}ω)		* *						*	*	*
d. ☞({[kuku'ma:ɟi]}ω)								*	*	*
d. ({['ku:ku'ma:ɟi]}ω)		* *	*	*					*	*

Tableau 1 shows that output form (a) is not optimal as it violates vowel lengthening constraints in the compound by having long vowel on both words of the compound. Constraint FAITH[Phon] has been violated by output forms **a**, **c**, and **d** by dropping stress and vowel length on the first word. Express{Affix$_{Num/Ncl}$} and $W_1\{Ncl.\}_{comp}\&_\delta W_1\{Affix_{Num}\}_{Comp}$ have been

violated by all output forms since they do not show noun class and number affixes. However, these constraints are weak and tolerable in evaluating compound nouns of this structure.

Output form (b) has violated the strong constraint which requires all compound nouns to form a single unit of meaning by combining together all its component words (morphologically and phonologically). Violating this constraint makes other constraints lose importance in the evaluation of the output; hence they are shaded.

Output form (c) has violated the stress placement constraint by having no stress on all words forming it. It has also violated FAITH(Phon) by dropping stress and vowel length from all words; so it is not optimal.

Output form (d) is the optimal form in this analysis since it has not violated any strong constraint except the weak ones FAITH(Phon) by dropping stress and vowel length on the first word of the compound as well as Express{$Affix_{Num/Ncl}$}and W_1{Ncl.}$_{comp}$&$_{\delta}W_1${$Affix_{Num}$}$_{Comp}$ which are weak in this analysis.

The last output (e) is not optimal as it has violated many constraints and some are strong. It has violated the constraints which require a compound to have one primary stress on the final word of the compound by having two primary stresses (on both words forming it). Moreover, it has violated a constraint that forbids the compound to have long vowel on the penultimate syllable of the first and the second word of the compound and Express{$Affix_{Num/Ncl}$}and W_1{Ncl.}$_{comp}$&$_{\delta}W_1${$Affix_{Num}$}$_{Comp.}$

mchumia ‘make money for’+juani ‘in the sun’ => mchumiajuani ‘proletariat’

({[mču'mi:a]}ω)Σ({[Ɉu'a:n i]}ω) => ({[mčumiaɈu'a:n i]}ω)

CONSTRAINTS:

{ωΣωΣ$_n$}&$_{\delta}$Erase)φ($_{\{comp\}}$&$_{\delta}$COMP^1(M^1)>>Stress$_1{}^1$(Comp.)>>Stress$_1${$W_{\#}\sigma_{\#}^{-1}$}$_{comp}$

&$_{\delta}$Vlength($W_{\#}\sigma_{\#}^{-1}$)$_{comp}$>>*Vlength($W_1\sigma_{\#}^{-1}\Sigma W_{n\#}\sigma_{\#}^{-1}$)$_{comp}$>>$W_1$(SemHead)$_{comp}$&$_{\delta}$INTE>>
Express{$Affix_{Num/Ncl}$}>>W_1{Ncl.}$_{comp}$&$_{\delta}W_1${$Affix_{Num}$}Comp>>Align(W,R;ω,R)$_{comp}$&$_{\delta}$Align(W,L;ω,L)$_{comp}$>>FAITH{Mor}>>FAITH[Pho]

Tableau 2 on the next page shows that output form (a) violates a strong constraint that needs compound noun to be a single unit of meaning and erase

all phonological-phrase boundaries between its component words. Therefore, other constraints lose their importance in the evaluation.

Output form (b) violates the constraint which requires that a compound noun must have one long vowel on the stress bearing syllable. This output form has long vowel on the penultimate syllable of the first word and on the second word. It has also violated FAITH{Mor} by affixing *m-* on the first word which basically do not take such an affix. Moreover, it violates FAITH[Phon] by inserting a new sound segment /m/ which was is not in the input form. Therefore, it is not optimal.

Tableau 2: "mchumiajuani"

	Set of Constraints									
Inputs {m-}, ({[ču'mi:a]}ω), ({[Ju'a:n i]}ω) Cat:N Meaning: proletariat	**{ωΣωΣn}&δErase)φ(comp)&δ COMP1(M1)**	**Stress1-1(Comp.)**	**Stress1{W#σ#1}comp&δ Vlength(W#σ#-1)comp**	***Vlength(W1σ#-1ΣWn#σ#-1)comp**	**W1(SemHead)comp&δINTE**	**Express{AffixNum/Ncl}**	**W1{Ncl.}comp&δW1{AffixNum}Comp**	**Align(W,R;ω,R)comp&δ Align(W,L;ω,L)comp**	**FAITH{Mor}**	**FAITH[Pho]**
a.({[mču'mi:a]} ({[ju'a:n i]}ω)	**!***									
b. ({[mčumi:a ju'a:n i]}ω)				*					*	*
c.☞ ({[mčumiaju'a: n i]}ω)									*	*
d. ({[mčumi:a ju'an i]}ω)			**						*	*
e.({[čumiaju'a: n i]}ω)					*	*	*			

Output form (c) is the optimal form of standard Swahili compound noun. It has satisfied all strong constraints except the tolerable weak constraints which are FAITH{Mor} by affixing {m-}on the first word, and

FAITH[Phon] by dropping primary stress and reducing vowel length on the first word and inserting a sound [m]. Violation of these weak constraints leads to the satisfaction of the strong constraints.

Output form (d) is not optimal as it violates the constraint which requires a vowel of the stress bearing syllable to be long (the vowel is short). Furthermore, it violates FAITH [Phon] by dropping stress on the first word and vowel length on the penultimate syllable on the second word and FAITH {Mor} by affixing {m-}.

The last output form which lost the chance to be optimal is form (e). It has violated Express{$Affix_{Num/Ncl}$} as it has not shown any noun class or affixes for numbers on the compound noun which is strong in this analysis. Therefore, the output is not recognised as a compound; hence it is uninterpretable.

Mwana'son'+jamii 'society'+lugha 'language'

=> mwanajamiilugha 'a member of a certain speech community'

({['mwa:na]})ωΣ({[ɟa'mi:i]})ωΣ({['lu:ɣa]})ω=> ({[mwanaɟamii'lu: ɣa]})ω

CONSTRAINTS:

{$\omega\Sigma\omega\Sigma_n$}&$_\delta$Erase)φ($_{\{comp\}}$&$_\delta$$COMP^1(M^1)$>>$Stress_1{}^1$(Comp.)>>$Stress_1${$W_{\#}\sigma_{\#}^{-1}$}$_{comp}$

&$_\delta$$Vlength(W_{\#}\sigma_{\#}^{-1})_{comp}$>>*$Vlength(W_1\sigma_{\#}^{-1}\Sigma W_{n\#}\sigma_{\#}^{-1})_{comp}$>>$W_1(SemHead)_{comp}$&$_\delta$INTE>>
$Express\{Affix_{Num/Ncl}\}$>>$W_1${Ncl.}$_{comp}$&$_\delta$$W_1\{Affix_{Num}\}Comp$>>$Align(W,R;\omega,R)_{comp}$&$_\delta$$Align(W,L;\omega,L)_{comp}$>>FAITH{Mor}>>FAITH[Pho]

Tableau 3. "mwanajamiilugha"

	Set of Constraints									
Inputs ({['mwa:na]})ω, ({[ɲa'mi:i]})ω, ({['lu:ɣa]})ω Cat:N Meaning: A member of a certain speech community	**{ωΣωΣn}&δErase)φ({comp}&δ COMP[1](M[1])**	**Stress[1](Comp.)**	**Stress[1]{W#σ#[-1]}comp&δ Vlength(W#σ#[-1])comp**	***Vlength(W1σ#[-1]ΣWn#σ#[-1])comp**	**W1(SemHead)comp&δINTE**	**Express{AffixNum/Ncl}**	**W1{Ncl.}comp&δW1{AffixNum}Comp**	**Align(W,R;ω,R)comp&δ**	**FAITH{Mor}**	**FAITH[Pho]**
a.({['mwa:na]})ω({[ɲa'mi:i]})ω({['lu:ɣa]})ω	!*									
b. ({[mwanaɲa'mi:i]})ω({['lu:ɣa]})ω	!*									
c. ({['mwa:naɲami:i'lu:ɣa]})ω		**	*	*						*
d. ☞ ({[mwanaɲamii'lu:ɣa]})ω										*
e. ({[mwana][ɲamii]['lu:ɣa]})ω					*			*		*

Output (a) in tableau 3 above is not optimal because it has not combined words forming it into a single unit of meaning (as one morphological and phonological word). The output is not a compound because its words are listed as separate words.

A similar situation is observed regarding the output form (b) which has not included the third word 'lugha' to make a compound as compared to the concept introduced by the input meaning. Therefore, other constraints have lost their importance in the evaluation.

Output (c) has two primary stress, so it violates $Stress_1{}^1$(Comp.) which requires a compound to have one primary stress. It has also violated a

constraint which requires a compound to have a primary stress and vowel length on the penultimate syllable of the final word as it has primary stress and long vowel on the penultimate syllable of the first word. Another constraint which has been violated is the one that forbids a compound noun to have long vowel on all words that form a compound noun. Lastly, it violates FAITH[Phon] by dropping stress on the second word. Therefore, the output has lost a chance to win the competition as an optimal Swahili compound.

Output (d) has won the competition to be an optimal form for a standard Swahili compound noun by satisfying all strong constraints. It has violated a weak constraint FAITH[Phon] by dropping primary stress and vowel length on the penultimate syllables of the first and the second word in order to meet the requirements set forth by the strong constraints.

Output (e) has violated the alignment constraint by not coinciding phonological edges with morphological edges and FAITH[Phon] by dropping stress on the second word. Therefore, it is also not interpretable.

> Uti 'spine'+wa 'of'+mgongo 'back' => uti wa mgongo 'spinal cord or severe fever attacking spinal scord and brain'
>
> ({['u:ti]})ωΣ({[wa]})ωΣ({[m'g:ŋgɔ]})ω=> ({[utiwam'gɔ:ŋgɔ]})

CONSTRAINTS:

$\{\omega\Sigma\omega\Sigma_n\}\&_\delta Erase)\varphi(_{\{comp\}}\&_\delta COMP^1(M^1)>>Stress_1{}^1(Comp.)>>Stress_1\{W_\#\sigma_\#{}^{-1}\}_{comp}$

$\&_\delta Vlength(W_\#\sigma_\#{}^{-1})_{comp}>>*Vlength(W_1\sigma_\#{}^1\Sigma W_{n\#}\sigma_\#{}^1)_{comp}>>W_1(SemHead)_{comp}\&_\delta INTE>>$
$Express\{Affix_{Num/Ncl}\}>>W_1\{Ncl.\}_{comp}\&_\delta W_1\{Affix_{Num}\}Comp>>Align(W,R;\omega,R)_{comp}\&_\delta Align(W,L;\omega,L)_{comp}>>FAITH\{Mor\}>>FAITH[Pho]$

With reference to the next tableau 4 (on the following page), output form (a) is not optimal because it has violated the strong constraint which forbids a compound noun to have morphological and phonological boundaries within it. The word *wa,* 'of', has not been combined with other words, a situation which renders a compound's pronunciation awkward and uninterpretable. So, other constraints lose their importance in the evaluation.

Output form (b) in tableau 4 is optimal because it has not violated any strong constraint except the weak FAITH[Phon] by dropping primary stress and vowel length in the first word so as to satisfy the strong constraints.

Output (c) has violated the requirement that noun class and number affixes be attached to the first word of the compound by affixing the plural affix {mi-} on the second word. It has also violated the weak constraint FAITH[Phon] by dropping primary stress and vowel length on the first word. So, it has lost the chance to win the competition.

Tableau 4. "uti wa mgongo"

	Set of Constraints									
Inputs ({['u:ti]})ω, ({[wa]})ω, ({[m'gɔ:ŋgɔ]})ω Cat: N Meaning: a severe fever attacking spinal cord and brain.	**$\{\omega\Sigma\omega\Sigma_n\}\&_\delta$Erase)$\varphi_{(comp)}\&_\delta$ COMP^1(M^1)**	**Stress$_1$^{1}(Comp.)**	**Stress$_1$$\{W_{\#\sigma\#}{}^1\}_{comp}\&_\delta$ Vlength$(W_{\#\sigma\#}{}^{-1})_{comp}$**	***Vlength$(W_1\sigma_{\#}{}^{-1}\Sigma W_{n\#\sigma\#}{}^1)_{comp}$**	**W_1(SemHead)$_{comp}\&_\delta$INTE**	**Express$\{Affix_{Num/Ncl}\}$**	**$W_1\{Ncl.\}_{comp}\&_\delta W_1\{Affix_{Num}\}_{Comp}$**	**Align(W,R;ω,R)$_{comp}\&_\delta$ Align(W,L;ω,L)$_{comp}$**	**FAITH{Mor}**	**FAITH[Pho]**
a.({[uti ({[wa]})m'gɔ:ŋgɔ] })ω	!*									
b. ☞ ({[utiwam'gɔ:ŋgɔ] })ω										*
c.({[utiwami'gɔ:ŋg ɔ]})ω							*			*
d. ({['u:tiwam'gɔ:ŋgɔ]})ω		* *		*						
e.({([utiwa])ω ([m'gɔ:ŋgɔ])ω})ω	!*									

Output (d) is also not optimal since it has violated a strong constraint which requires a compound noun to have one primary stress. This form displays primary stress on the first and the final word. Moreover, it has violated a constraint which forbids a compound noun to have a long vowel on

penultimate syllables of all words that form it. It has a long vowel on the word *uti* 'spine' and *mgongo* 'back'.

The last output in the tableau, output (e), has lost the chance to win by inserting phonological boundaries within it and so has become uninterpretable. Therefore, other constraints are shaded because of the violation of this strong constraint.

Conclusion

This analysis of morphological, phonological and semantic constraints' interactions in forming compound nouns can be used to analyse all compound nouns in standard Swahili. The examples given above are representations of all compound nouns' structures found in standard Swahili.

As for compound noun formation, we can summarise the results gathered here as follows: it has been discovered that a compound noun form has to satisfy requirements set forth by the constraints of all grammatical modules for it to be grammatically optimal and acceptable to the speech community. Violating morphological, phonological, or semantic constraints makes a compound produced uninterpretable, hence unacceptable to the Swahili speech community.

The phonological aspects that interact with morphological (merging operation and affixation) and semantic (meaning) constraints in forming compounds are stress, vowel lengthening, and intonation (phonological-phrase boundaries). These three phonological aspects play a major role in forming optimal compound nouns. Moreover, when a compound noun has satisfied phonological constraints but violates morphological constraints, such as affixation constraints, the output form of the compound noun loses a chance to be optimal in standard Swahili grammar.

When a morphological operation combines two or three words to form a compound noun, primary stress on all words except the final word drops. This is because, phonologically, in standard Swahili a word has only one primary stress with its longest vowel on that stress bearing syllable. Furthermore, it has been observed that intonation at the phonological-phrase level has some effects on the grammaticality and interpretability of the compound form. Phonological-phrase boundaries between two or three words forming a compound have to be erased so that a compound can be pronounced as one word. So, there are no pauses between boundaries of these words. All these conditions prove that there is an interface between morphology, phonology and semantics in forming compound nouns in standard Swahili.

This paper has demonstrated how a constraints approach can be used to analyse linguistic phenomena, by using the case of interaction between morphology, phonology and semantics in compound nouns of standard Swahili language. Thus optimality theory is shown to be useful in illuminating the realisation of this complex interface of traditionally distinguished linguistic aspects in the formation of standard Swahili compound nouns.

A constraints approach is capable of illuminating the interaction between more than two grammatical modules in a single analysis, as opposed to rule-based theories which need some derivational stages to address the phenomena of interest. The interaction can be shown by constraints arrangement and constraints conjoining. This work paves the way for augmenting other research foci using optimality theory. The constraints approach was initially introduced to deal with phonological aspects. But more recently it has been used in other linguistic fields such as semantics, syntax, morphology, language acquisition, pragmatics, and language typology. This expanding trend might continue, whereby a constraints approach will be found to prove useful in dealing with cognate fields including sociolinguistics, applied linguistics, comparative African cultural studies. Humanities researchers may find this approach useful in studying other fields of representational communication that preserves cultural heritage as well.

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