

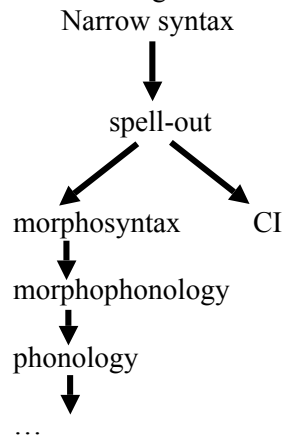
Three types of linearization and the temporal aspects of speech*

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1. The road to PF

Linearization is a commonly used term in many domains of linguistic theory. The purpose of this paper is to clarify what linearization is by demonstrating that it is not a monolithic nor unified operation. Instead, linearization occurs as a by-product of the necessary conversion of representations from one grammatical module to another. The transfer of a representation from one module to another requires a conversion in content since different modules traffic in different representations and concomitant computations. As a starting point, we assume the grammatical organization in (1).

(1) Organization of the grammar



Within the model in (1) we argue that there are three distinct places where linearization occurs. All forms of linearization occur after the representation has left the narrow syntax and occur as part of the externalization

(Berwick and Chomsky forthcoming) of language. This means that the model in (1) is more detailed along what is usually referred to as the phonetic form/sensory-motor (PF/SM) path. At the spell-out point, we must note that the purely hierarchical representation built by the narrow syntax is sent off to the conceptual-intention areas (CI) prior to any type of linearization (the operative assumption here being that linear order is not a property of the CI representational system). The split in the path of the representation marks the beginning of the externalization and linearization of the syntactic object.

There are three types of linearization and they are each associated both with a particular grammatical submodule and the addition (and possible removal) of specific types of relationships between atoms of representation. The *narrow syntax* (Chomsky 2007) module remains intact and only utilizes hierarchical relationships created by merge (external or internal) between syntactic elements. The narrow syntax ships off representations to the *CI interface* and the *morphosyntax* module. The representations in the morphosyntax module are distinct from the representations in the narrow syntax because in addition to hierarchical relationships there are now adjacency relationships present (Marantz 1988, Embick and Noyer 2001). This is the first type of linearization to occur and we define the addition of adjacency relations as *immobilization*, as this step reduces the mobility of items declared adjacent. At this point, the morphosyntactic representation contains hierarchical and adjacency relations among morphosyntactic features but there is as yet no phonological content present. *Vocabulary insertion* is the process which exchanges morphosyntactic features for phonological representations. The linearization aspect of vocabulary insertion is that the hierarchical and adjacency relations from the morphosyntax are traded for precedence relations among phonological segments. *Morphophonological* representations consist only of phonological and morphological material so they are limited to segments, precedence relations (see below), any prosodic structure projected from the segments and morphological diacritics. Finally, morphophonological representations will be *serialized* into *phonological* representations which conform to a strict linear ordering (i.e., a total, asymmetric and non-reflexive ordering) and which only contain phonological material and diacritics. For the purposes of this paper, we will equate the phonological representation with PF and assume that there are further complex transformations (e.g. converting phonological features to continuous phonetic features, phonetic features to gestures, etc.) in the phonetic component

which result in a representation interpretable at the SM interface. (2) summarizes the nature of representation in these four modules.

(2) The path from narrow syntax to PF

Module	Characteristics
<i>Narrow syntax</i>	hierarchy, no linear order, no phonological content
LINEARIZATION-1 = Immobilization	
<i>Morphosyntax</i>	hierarchy, adjacency, no phonological content
LINEARIZATION-2 = Vocabulary Insertion	
<i>Morphophonology</i>	no hierarchy, directed graph, phonological content
LINEARIZATION-3 = Serialization	
<i>Phonology</i>	no hierarchy, linear order, phonological string

We will demonstrate the distinctions in linearization based on each module by analyzing a single example of Echo Reduplication (ER) in Kannada (Lidz 2001). ER in Kannada provides a rich example that demonstrates the necessary representational aspects of each grammatical module. The layout of this chapter is as follows. Section 2 discusses our assumptions about narrow syntax and what aspects of the ER pattern should be accounted for in this module. Section 3 discusses our assumptions about morphosyntax and the aspects of ER that are explained in this module. Section 4 demonstrates how a morphosyntactic representation is converted to a morphophonological one via vocabulary insertion and the relevant aspects of ER that are accounted for. Section 5 briefly discusses phonological aspects of ER that must be accounted for prior to the representation being passed onto the phonetics module. Finally, Section 6 provides a conclusion and discusses how a linearization based approach to linguistic representations provides insights into the atemporal aspects of language as identified by Lashley (1951).

2. The syntax of ER

Kayne (1994), *The antisymmetry of syntax*, is a milestone in the research program to understand the role of linear order in the narrow syntax. The current instantiation of this line of inquiry about syntactic representations begins with Barss and Lasnik (1986) and continues with structural analyses (Larson 1988, Pesetsky 1995 among others) which remove the need for linear order in the explication of various constructions. The operative conclusion of this line of research is that linear order is superfluous in

syntax. The strongest version of these proposals is Kayne's (1994) *Linear Correspondence Axiom* in (3).

(3) Linear Correspondence Axiom: $d(A)$ is a linear ordering of T .

Kayne (1994:49) states:

“[T]he LCA is the source of all the major properties of phrase structure that have been attributed to X-bar theory...It follows that to declare the LCA inapplicable to some level of representation—say, LF—would be to declare inapplicable to that level of representation all the restrictions on phrase structure familiar from X-bar theory...”

Kayne's LCA tightly yokes hierarchical representation and linear order in that linear order is derivable from the hierarchical representations in the narrow syntax. Consequently, a difference in linear order necessarily requires a difference in syntactic structure according to the LCA. This means that basic word order generalizations such as spec-head-complement vs. spec-complement-head coincide with distinct syntactic structures with one structure being derived from the other. Kayne (1994) argues that the basic linear order of an XP is spec-head-complement (e.g. SVO, English) while Takano (1996) argues that the basic linear order is spec-complement-head (e.g. SOV, Japanese). The point of contention between these two points of view is which of the two linear orders requires an extra movement in order to be derived. Working within the constraints of the LCA, one of the two orders must be derived by moving the complement to produce a different hierarchical relationship with the head of the phrase.

Many have already noted that Kayne's version of the LCA is too strong and must be reinterpreted. For example, internal merge (Chomsky 2007) creates syntactic objects which violate the LCA. Anytime internal merge operates, a symmetrical relationship will be created and this violates the LCA. Any model of syntax which adopts a copy theory of movement contains this conflict between syntactic movement and the LCA.

Kayne's proposals on antisymmetry are usually interpreted as indicating syntactic structure determines and fixes linear order. This is one way to interpret linear relationships being inert in the narrow syntax. Another way to interpret the inertness of linear order in syntactic representations is proposed by Chomsky (2007) and Berwick and Chomsky (forthcoming).

Chomsky (2007) suggests that Merge (internal or external) does not encode linear order thus only hierarchy is represented in the narrow syntax. Consequently, the “LCA can plausibly be interpreted as part of the mapping to the SM interface” (Chomsky 2007:10). Berwick and Chomsky further develop this idea stating, “...ordering is restricted to externalization of internal computation to the sensorimotor system, and plays no role in core syntax and semantics...” (Berwick and Chomsky, forthcoming: 9).

The complete removal of linear order from the narrow syntax highlights the importance of a modular approach to ordering effects. Each distinct grammatical module will alter the characteristics of the representation to suit the particular computations that need to be accomplished. Distributed Morphology (Halle and Marantz 1993, 1994) is particularly well suited to demonstrating the distinct representational aspects of different modules. Perhaps the most important aspect of DM in our understanding of how linearization is achieved is the principle of Late Insertion. Late Insertion proposes that no phonological material is present in the narrow syntax or morphosyntax modules. If precedence relations (Raimy 2000) which encode linear order are fundamentally phonological in nature then adopting the DM position of Late Insertion derives directly the inertness of linear order in the narrow syntax. The importance of the relationship between Late Insertion and linear order has been overlooked previously.

We can now turn to the examples of ER in Kannada (Lidz 2001) that we will use to demonstrate the different stages of linearization. We assume the general analysis of Kannada and ER from Lidz (2001, 2004) and Lidz and Williams (2006). (4) presents examples of ER which show the basic surface linear order (SOV/S-C-H) and the possible variations in the extent of the reduplicated material in ER. Note that the phonological material which indicates what the syntactic base for reduplication is is indicated in square brackets while the actual repeated (and partially phonologically prespecified material) is underlined.

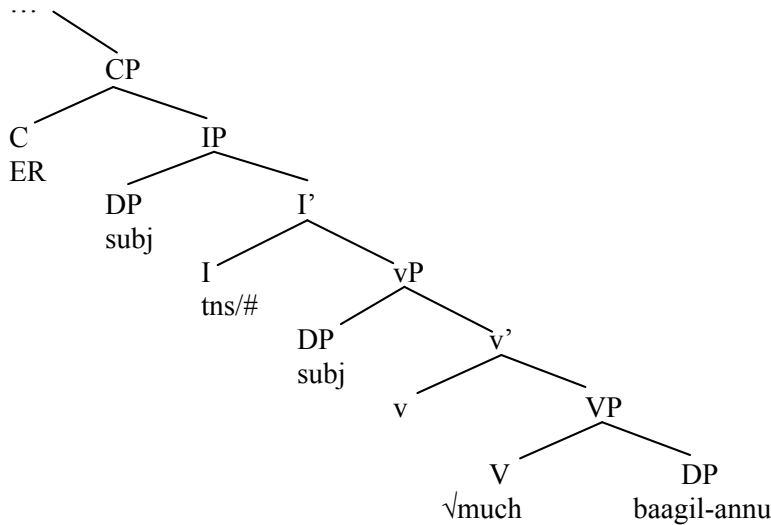
(4) ER in Kannada (Lidz 2001:388-389)

- a. *baagil-annu [much]-gich-id-e anta heeLa-beeDa*
 door-ACC close-RED-PST-1S that say-PROH
 ‘Don’t say that I closed the door or did related things’
- b. *baagil-annu [much-id-e]-gich-id-e anta heeLa-beeDa*
 door-ACC close-PST-1S-RED that say-PROH
 ‘Don’t say that I closed the door or did related things’

- c. *nannu* [*baagil-annu* *much-id-e*] *giigilannu muchide* *anta*
 heeLa-beeDa
 I-NOM door-ACC close-PST-1S RED that
 say-PROH
 ‘Don’t say that I closed the door or did related activities’
- d. [*baagil-annu*] *giigilannu* *much-id-e*
 door-ACC RED close-PST-1S
 ‘I closed the door and related things’

The syntactic analysis of ER should account for the syntactic phenomena (and by implication through CI the semantic phenomena) and only the syntactic and semantic phenomena. Consequently, the tree in (5) is necessary and sufficient to capture the syntactic aspects of (4a-c).

(5) ER syntax for embedded VPs in Kannada (hierarchy only)

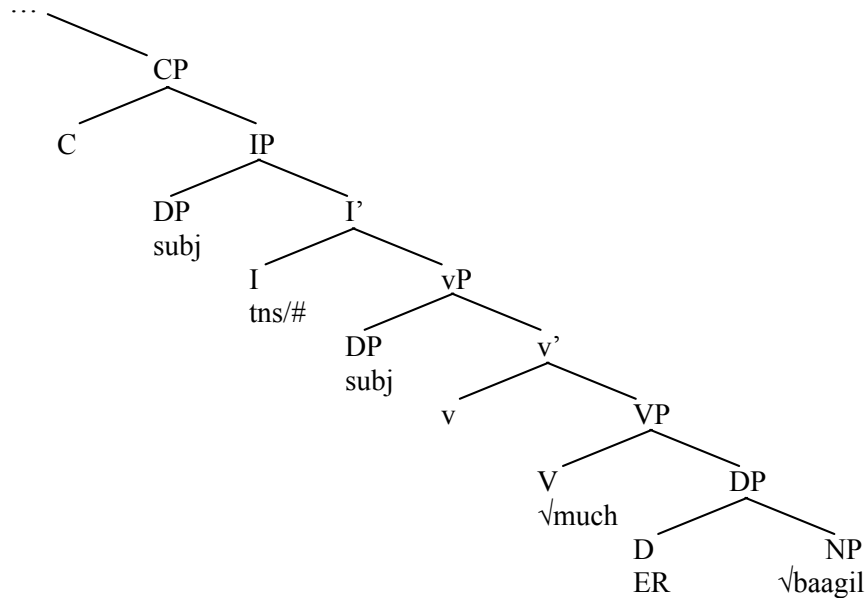


The important syntactic aspects of (5) are that by placing the ER morpheme in C a first pass at whether ER is allowed in an embedded clause (Lidz 2001:388) is achieved and that the semantic scope of the ER reading is correct. (4a), (4b) and (4c) all have the syntax of (5) even though there are different surface realizations of ER. The differences in the repeated regions among (4a), (4b) and (4c) do not cause any difference in the inter-

pretation of the examples. All of these examples have the ‘...and did related things’ reading where ‘close’ is in the scope of ER so ‘related things’ are connected to ‘door closings’ (e.g. latching, locking, pulling down of shades, etc.) (Jeff Lidz, p.c.). As long as the verb is part of the reduplication pattern, this interpretation obtains regardless of how much is actually reduplicated. Since there is variation in the reduplication pattern but not in the semantics of the patterns, we will account for this variation in the morphosyntax and not in the narrow syntax. The variation in what is actually repeated as part of ER should not (cannot) be accounted for by the narrow syntax because of the grammatical architecture in (1). Since spell-out sends the syntactic representation to CI for interpretation, we want the syntactic structure in (5) to be sent to CI for all three sentences in (4a), (4b) and (4c) because they all have the same meaning.

In contrast, in (4d) the verb is not in the (semantic) scope of ER. This means that the ‘related things’ are connected to the DP ‘doors’ such as windows but all events are closings (Jeff Lidz, p.c.). This is a semantic distinction that must be captured in the narrow syntax, inducing a different CI representation. Consequently for (4d), we will base generate the ER morpheme down in DP as in (6).

(6) ER syntax for DPs in Kannada



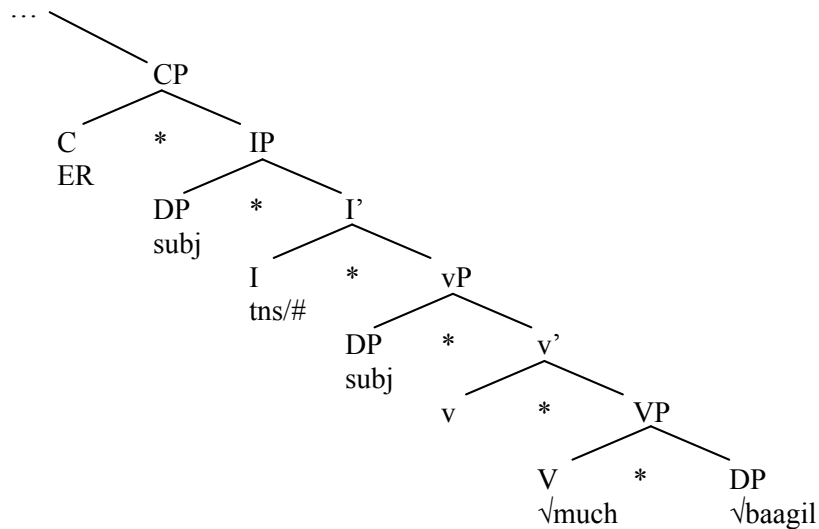
By base generating the ER morpheme inside DP, it will not have semantic scope over the verb and thus derives the different semantic interpretations between (4d) and (4a), (4b) and (4c).

The narrow syntax only encodes hierarchical relationships and these relations must determine the relevant semantics for the CI module. All other aspects of the examples in (4) such as the linear order of SOV or the variation in reduplicated regions in (4a), (4b) and (4c) are not determined by the narrow syntax nor should they be.

3. The morphosyntax of ER

Operations in the morphosyntax will account for some aspects of linear word order and the variation in the ER patterns. The interface between the narrow syntax and the morphosyntax imposes adjacency relations (Sproat 1985, Embick and Noyer 2001) in the representations. *Immobilization* is the process that adds adjacency information to hierarchical information and adjacency is indicated by * in (7) (following Sproat 1985).

(7) Immobilized tree for ER in embedded VPs



Immobilization does not create a complete linear order because mirror images of hierarchical adjacency structures are equivalent but not all orderings of syntactic elements are admissible as shown in (8).

(8) Equivalency under adjacency

- a. $[A * [B * C]] = [[B * C] * A] = [[C * B] * A] = [A * [C * B]] \neq [C * A * B]$
- b. $[_{CP} ER * [_{IP} \emptyset * [_{I'} tns/\# * [_{VP} \emptyset * [_{V'} v * [_{VP} \sqrt{much} * [_{DP} \sqrt{baagil}]]]]]]]]]$
- c. $[_{CP} [_{IP} \emptyset * [_{I'} [_{VP} \emptyset * [_{V'} [_{VP} [_{DP} \sqrt{baagil}] * \sqrt{much}] * v]]] * tns/\#]] * ER]$

Adjacency information added by immobilization is required to properly define the operation of morphological merger (Marantz 1988). The morphosyntax can also perform other operations such as addition of morphemes, fusion, fission and impoverishment (Halle and Marantz 1994). None of these processes are relevant to the aspects of ER treated here.

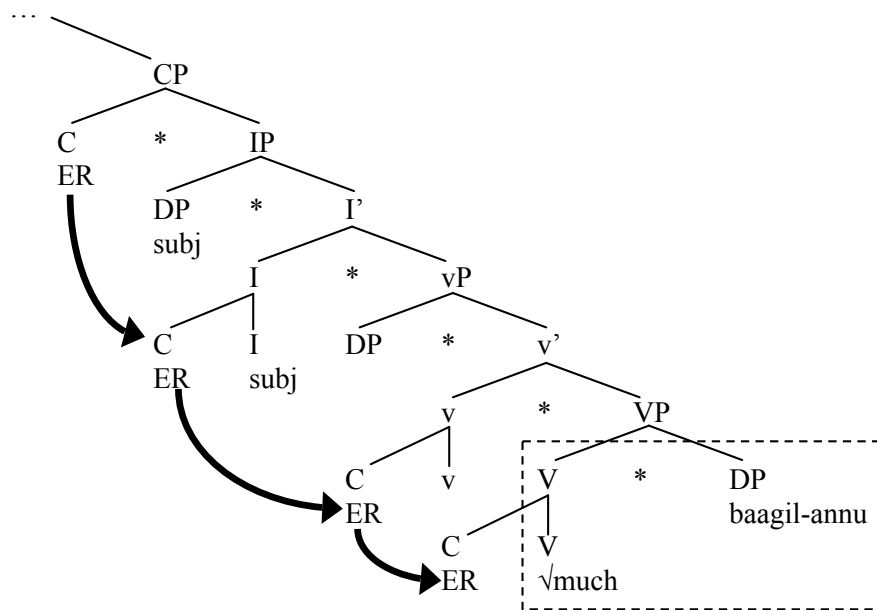
The morphosyntax can also perform the operation of lowering (Embick and Noyer 2001). Lowering the ER morpheme from its base generated position of C will account for the variation in what is reduplicated in (4a), (4b) and (4c). We will set aside the ER pattern in (4d) because it is base generated low in the DP and thus does not appear to lower any further. Since lowering occurs in the morphosyntax after the narrow syntax has sent a representation to the CI interface, the movement of the ER morpheme will not affect its semantic interpretation. This is exactly what we want, given the equivalent readings of (4a), (4b) and (4c).

To account for the variation in what is reduplicated in (4a), (4b) and (4c), we will allow lowering to move the ER morpheme in three distinct ways. There is an inverse relationship between how much material is reduplicated and how far down the tree the ER morpheme is lowered. This relationship holds because of how cyclic vocabulary insertion operates in that only the parts of the tree that have undergone vocabulary insertion prior to the insertion of the ER morpheme are eligible to be repeated. Thus, the morphosyntactic scope of the ER morpheme determines what can be repeated as part of the reduplication pattern. (9) indicates where the ER morpheme moves to and what is repeated as part of the reduplication pattern.

(9) Reduplicated form	C head lowers to
4a. much- <u>gich</u>	V
4b. muchide- <u>gichide</u>	V with I
4c. baagil-annu much-id-e <u>giigilannu muchide</u>	I

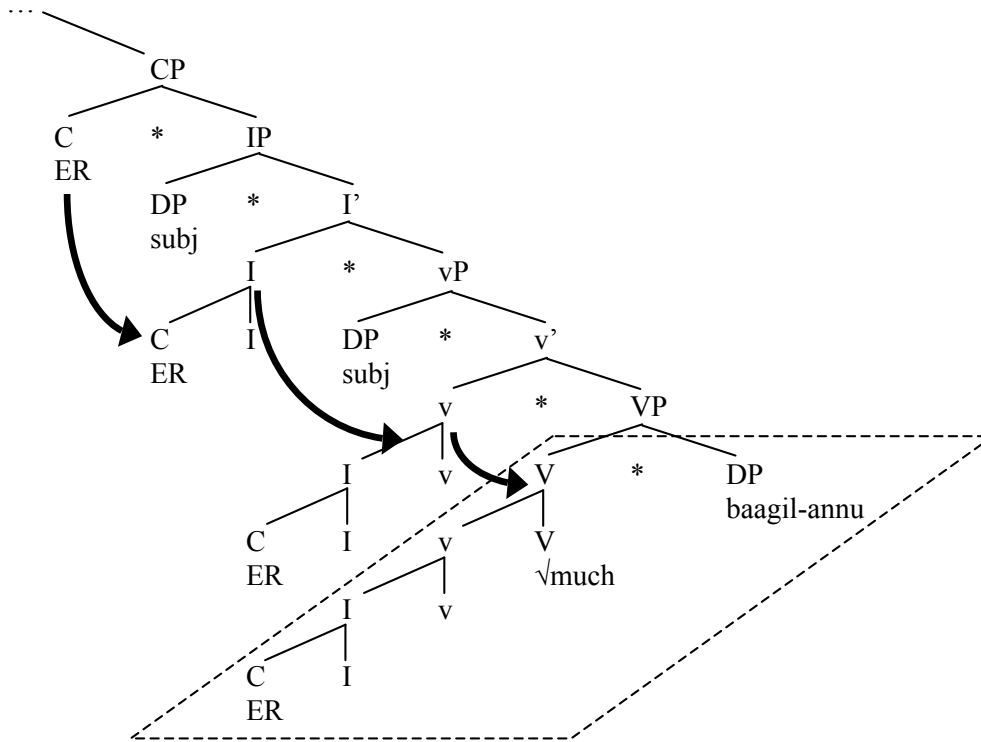
The morphosyntactic tree that results from the successive lowering of the ER morpheme all the way down to the V head is shown in (10). As part of this movement the ER morpheme will lower from C to I, from I to v and finally from v to V. In the final position of sister to the V head, only the V head is in the morphosyntactic scope of the lowered ER morpheme. The position of the ER morpheme in the morphosyntactic tree determines when the ER morpheme will be converted to phonological material due to vocabulary insertion. Consequently, only morphemes (now phonological material) that have already undergone vocabulary insertion are eligible to be repeated as part of the reduplication pattern. The dotted box in (10) identifies what parts of the tree will have undergone vocabulary insertion when the ER morpheme undergoes vocabulary insertion. The amount of phonological material already present that will be repeated is dependent on morphophonological issues that will be dealt with in the next section. Remember that there is still yet no linear order in the morphosyntax so the fact that the lowering operation is drawn with a left branching structure is purely due to graphic convenience.

- (10) Successive ER to V lowering to produce (9/4a)
much-gich



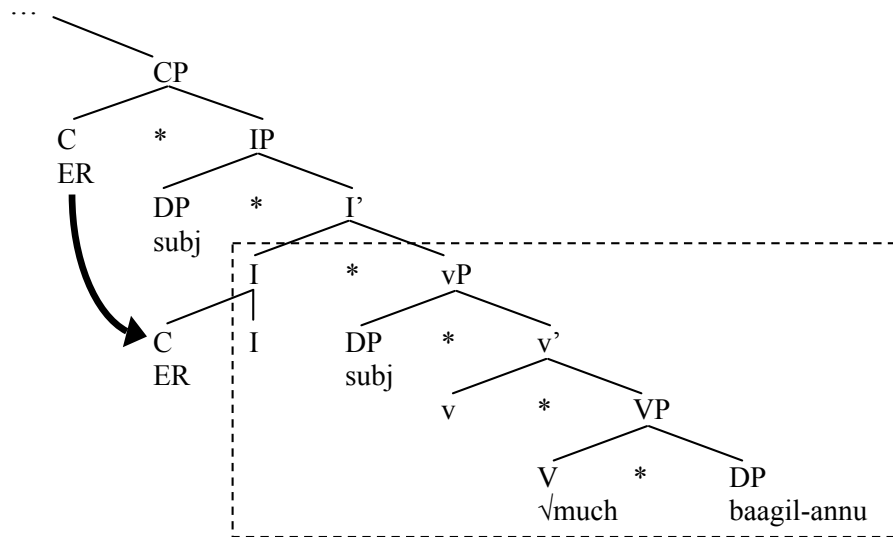
Now compare (11) which presents the final morphosyntactic structure for the ER pattern where the verb root plus suffixes is repeated as in (9/4b). The lowering process that produces this pattern is very similar to the one that produces the tree in (10). The difference between the two morphosyntactic structures is that in (11) the ER morpheme first lowers to I and then the ER morpheme and I head are lowered together as a complex to v. Finally, the whole v+I+ER morpheme complex is lowered to V. The end result is a head-adjoined complex consisting of ER+I+v+V in (11) as opposed to simply an ER+V complex in (10). Another difference between (10) and (11) is how much phonological material is potentially part of the reduplication pattern. Because the I and v heads lower to V along with the ER morpheme, they are eligible to be part of the ER pattern. In contrast, the I and v heads are not eligible to be copied as part of the ER pattern in (10) because they have not been lowered.

- (11) ER lowering to I and I+ER lowering to V to produce (9/4b)
muchide-gichide



The final ER pattern that we will explicate with a morphosyntactic tree is the pattern where the entire VP including object is repeated in (9/4c). This pattern is also produced via a lowering process but the ER morpheme only lowers to I and no further. (12) presents this tree and as before the dotted box indicates what parts of the tree are spelled-out at the time the ER morpheme is. From one viewpoint, the material available for repetition in (11) and (12) are the same in that I, v, V and the object have all undergone vocabulary insertion. The difference between (11) and (12) is in the morphosyntactic structure which will determine the order in which the morphemes undergo vocabulary insertion. This order will be discussed in the following section on morphophonology.

- (12) ER lowering to I to produce (9/4c)
baagil-annu much-id-e giigilannu muchide



The relevant morphosyntactic aspects of ER in Kannada have now been discussed. The morphosyntax has produced three distinct representations via different applications of lowering for the morphophonology to interpret. The important aspect of these morphosyntactic representations is that they determine the order in which morphemes will undergo vocabulary insertion. Thus, different morphosyntactic representations will provide different derivations of how the ER examples are converted to phonological representations.

4. The morphophonology of ER

The morphophonology module converts the morphosyntactic representation to a phonological representation through vocabulary insertion (Embick and Noyer 2001) through cyclic spell-out of the morphosyntactic tree. Cyclic spell-out determines the order in which the morphemes are traded for phonological material via vocabulary insertion.

4.1. Aspects of phonological representations

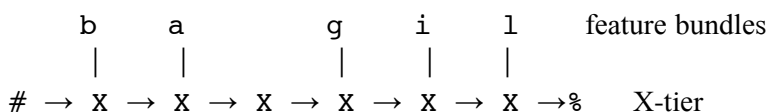
Memorized phonological forms are abstract in that they consist of bundles of distinctive features and precedence relationships between these bundles with both features and precedence relationships able to be manipulated (Raimy 1999, 2000). The phonological content of the encyclopedia of morphemes for Kannada in (13) is based on proposals in Raimy (2000) in that phonological representations contain precedence relations and are autosegmental (Goldsmith 1976). There are three novel symbols in these representations; $\rightarrow$ is the precedence symbol thus $A \rightarrow B$ means A precedes B, # is the ‘start’ symbol which indicates the beginning of a representation and % is the ‘end’ symbol which indicates the end of a representation. All three of these new symbols are required to specify what a well formed morphophonological representation is.

(13) Partial Kannada encyclopedia

roots	semantics	phonology
/baagil/	√door	# $\rightarrow$ b $\rightarrow$ a $\rightarrow$ X $\rightarrow$ g $\rightarrow$ i $\rightarrow$ l $\rightarrow$ %
/much/	√close	# $\rightarrow$ m $\rightarrow$ u $\rightarrow$ c $\rightarrow$ h ¹ $\rightarrow$ %
/doDDa/	√large	# $\rightarrow$ d $\rightarrow$ o $\rightarrow$ D $\rightarrow$ X $\rightarrow$ a $\rightarrow$ %
affixes	semantics	phonology
/annu/	Accusative	{_ %} $\rightarrow$ a $\rightarrow$ n $\rightarrow$ X $\rightarrow$ %
/id/	Past	{_ %} $\rightarrow$ i $\rightarrow$ d $\rightarrow$ %
/e/	1S	{_ %} $\rightarrow$ e $\rightarrow$ %
redup.	semantics	phonology
/gi/	‘and stuff...’	{_ %} $\rightarrow$ g $\rightarrow$ i $\rightarrow$ {1st V _}

The phonological representations in (13) do not fully indicate autosegmental structure. Each segment in (13) should be interpreted as a bundle of distinctive features with the specific content being indicated by the segment symbol and a separate X-slot. Precedence relations only occur among the X-slots themselves which means ordering relationships between distinctive features/segments are derived from the X-tier only. As part of autosegmental representations, ‘long’ segments can be represented by a fully specified segment (e.g. bundle of distinctive features associated with an X-slot) followed by an empty X-slot as in (14) which the phonology component later further modifies.

(14) Autosegmental representation of ‘long’ segments



An additional feature of the morphophonological representations is that there is a fundamental representational distinction between ‘roots’ and ‘affixes’. A root can be defined as a morphophonological representation which is a connected graph (Chartrand 1977:41-42) between # and %. An affix can be defined as a morphophonological representation which is not connected between # and %. The affixes in (13) are identifiable by the anchor point (Raimy 2009) which is contained in their representation. Anchor points are indicated in (13) by a phonological environment enclosed in curly brackets. Raimy (2009) provides a constrained theory of possible anchor points and the only two anchor points relevant for our discussion are {_%} which is ‘the last segment’ (i.e. the segment which points to %) and {1st V _} which is ‘the segment after the first vowel’. Because affixes contain at least one anchor point which will always replace either # or %, affixes are by definition not connected.

A further morphophonological distinction is encoded in differences among types of affixes. Concatenative morphology (e.g. prefixes and suffixes) can be defined in the present theory as morphophonological representations which contain a single anchor point. Because anchor points must replace either # or %, any morphophonological representation containing a single anchor point will contain either # or %. If the affix contains # then it is a prefix because the phonological material will occur before the phonological material it attaches to. If the affix contains % then it

is a suffix because it will occur after the phonological material it has attached to. If an affix contains two anchor points thus replacing both # and % then it is some sort of non-concatenative morphology such as infixation, reduplication or root-and-template morphology.

4.2. Linear order and precedence in morphophonology

Strict linear order is not introduced by vocabulary insertion done in a cyclic manner ordered by the morphosyntactic structure (Embick and Noyer 2001). Phonological roots need to be linearly ordered before or after phonological material and need to acquire this ordering information directly from the morphosyntactic representation. Morphosyntactic trees have been immobilized and thus contain adjacency relations, *, and part of spell-out is the conversion of adjacency to precedence. We assume that this conversion process is parameterized in the spell-out process because of our rejection of the strong interpretation of Kayne's LCA (see section 2). We also follow a Lidz and Idsardi (1998) approach to 'chain interpretation' where multiple copies of a (morpho)syntactic feature under go vocabulary insertion resulting as phonological material or as phonologically null based on their structural position in the chain and not a Nunes (2004) 'LCA satisfaction' approach.

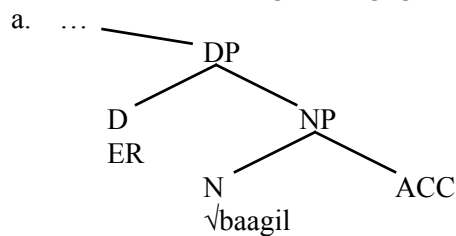
Affixes, as opposed to roots, contain inherent precedence information based on the presence of at least one anchor point. A well-formed phonological representation must have all anchor points 'discharged' by concatenating to the segment which satisfies the anchor point's structural description. The requirement for a well formed representation will override any precedence information imposed by morphosyntactic adjacency. An example of a conflict between precedence specified by morphosyntactic adjacency and precedence information inherent in an affix is infixation. Morphosyntactic representations that contain both adjacency and hierarchical relations do not support the concept of 'infixation' in that there is no way for one morpheme to be inside another at this level of representation. The morphosyntactic representation will specify each morpheme to be ordered either before or after the phonological material already present from prior applications of vocabulary insertion. At the morphophonological level though, an infix is simply a phonological representation that has two anchor points. Since each anchor point will specify some position other than % or #, the phonological exponence of the mor-

pheme will necessarily conflict with the ordering information derived from adjacency. In cases like this, the phonological information contained in the anchor points trump the adjacency from the morphosyntax. Reduplication is another case of this type where an affix has two anchor points with the difference between infixation and reduplication being the temporal relationship between the two anchor points. Infixation results when the first anchor point describes a position in the stem that precedes the position described by the second anchor point. Reduplication results when the first anchor point specifies a position in the stem that follows the position described by the second anchor point.

Cyclic vocabulary insertion is ordered by the hierarchical structure of the morphosyntactic representation. Ordering is derived from the category status (maximal vs. minimal projections) and c-command. The lowest maximal projection (i.e. one which does not c-command any other maximal projections) undergoes vocabulary insertion first. If there are multiple minimal projections (i.e. heads) within a maximal projection, the head of the maximal projection is spelled out first.

(15) presents the derivation for the ER pattern from (4d) where only the object (and none of the verb complex) is reduplicated. This pattern results from the ER morpheme being base generated in the D head and how cyclic spell-out operates. The tree structure in (15a) indicates that the NP is lower than the DP so vocabulary insertion will occur within the NP prior to vocabulary insertion in the DP. Within the NP, there are the N head $\sqrt{\text{baagil}}$ and the ACC head which has been inserted into the NP as part of the morphosyntax. Because both $\sqrt{\text{baagil}}$ and ACC are heads, the N head $\sqrt{\text{baagil}}$ will undergo vocabulary insertion first because it is the head of the NP. This creates the order of vocabulary insertion in (15b), (15c) and (15d).

(15) Derivation of ER: *baagilannu giigilannu*



b. VI $\sqrt{\text{baagil}}$ ‘door’

$\# \rightarrow b \rightarrow a \rightarrow X \rightarrow g \rightarrow i \rightarrow l \rightarrow \%$

c. VI ACC ($\{_ \%\} \rightarrow a \rightarrow n \rightarrow X \rightarrow \%$)

$\# \rightarrow b \rightarrow a \rightarrow X \rightarrow g \rightarrow i \rightarrow l \rightarrow \%$
 $\swarrow \quad \nwarrow$
 $a \rightarrow n \rightarrow X$

d. VI ER ($\{_ \%\} \rightarrow g \rightarrow i \rightarrow \{\text{1st V } _ \}$)

$\# \rightarrow b \rightarrow a \rightarrow X \rightarrow g \rightarrow i \rightarrow l \rightarrow \%$
 $\swarrow \quad \nwarrow$
 $a \rightarrow n \rightarrow X$
 $\searrow$
 $g \rightarrow i$

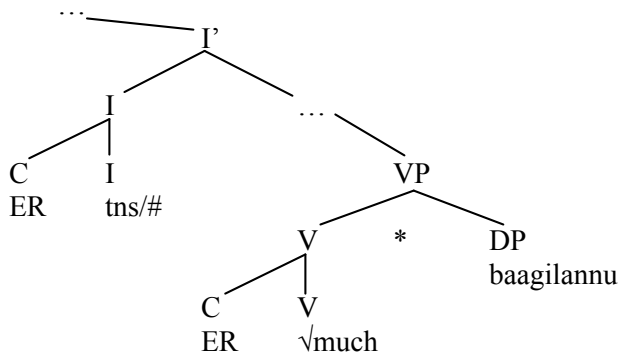
(Note: A curved arrow in the original diagram points from the 'g → i' segment back to the 'X' segment in the main sequence.)

(15b) is the first application of vocabulary insertion where the root $\sqrt{\text{baagil}}$ is converted from a morphosyntactic feature complex to a phonological representation. The ACC morpheme undergoes VI next which produces (15c). ACC is a suffix so it contains the ‘last segment’ anchor point. When the ACC morpheme undergoes vocabulary insertion, the anchor point calculates which segment satisfies the structural description of ‘last segment’. The ‘last segment’ is the /l/ of /baXgil/ because at this point in the derivation, it is the only segment which precedes %. Finally, (15d) shows the insertion of the ER vocabulary item. ER has two anchor points and segmental material. The begin anchor point specifies that /gi/ follows the ‘last segment’. Each anchor point makes its own calculation on what phonological material is presently available. The bare X slot which is the end of the ACC morpheme is now the ‘last segment’ according to this calculation because it immediately precedes % and transitively follows the other segment which immediately precedes % (/l/ of $\sqrt{\text{baagil}}$). The other anchor point in (15d) specifies that /gi/ precedes the ‘segment after the first vowel’. There is no ambiguity in this calculation. This completes the conversion of the morphosyntactic structure in (15a) to the morphophonological representation in (15d).

4.3 Derivations of Echo Reduplication

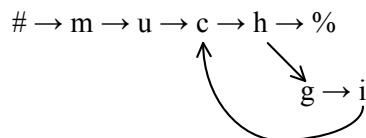
The example in (15) demonstrated how the morphosyntactic structure determines the order of vocabulary insertion for morphemes. Consequently, different morphosyntactic structures will produce different derivations even if they are composed of identical morphemes. Section 3 presented how the different surface patterns of ER in (4a), (4b) and (4c) were accounted for by different applications of lowering in the morphosyntax. We will now show how these different morphosyntactic representations produce different morphophonological representations based on when different morphemes undergo vocabulary insertion.

(16) is a simplified version of the representation in (10) where only the verb root is repeated as part of ER. This morphosyntactic representation focuses on when particular morphemes undergo vocabulary insertion.

(16) Morphosyntax of [*much*]-*gich-ide*, (4a)

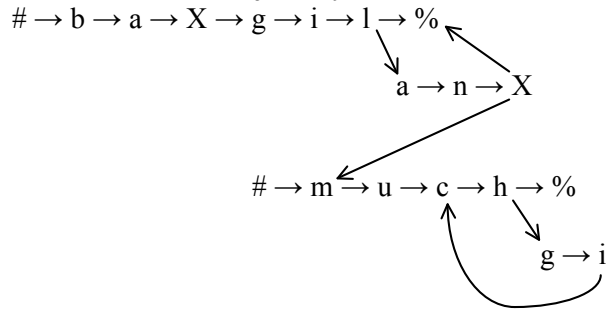
Because of the head-head structure underneath the V head node, these two morphemes will be spelled-out prior to the interpretation of the adjacency relationship between the V complex and its DP object. The V head will undergo VI first and then the ER morpheme will concatenate to it (in an analogous manner to [15d]) which produces the morphophonological structure in (17).

(17) Insertion and concatenation of C+V complex



At the point in the VI of the morphosyntactic structure in (16) where the VP node is reached there are two separate morphophonological representations because both the C+V complex (17) and the DP (15c) will have been converted to morphophonological representations. Both of these representations are connected within themselves so they must be ordered in relation to each other. This is where the VI process converts adjacency relations into precedence relations. Kannada has surface S-C-H order so the adjacency relationship between V and DP in (16) will be converted to one of precedence where the morphophonological representation of the DP, (15c), will precede the representation in (17). This produces the representation in (18).

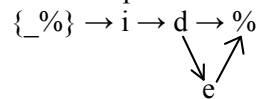
(18) Linear order from adjacency



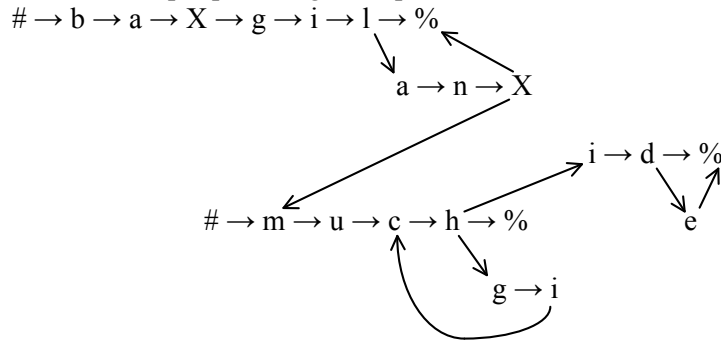
The final step in the complete conversion of (16) to a morphophonological representation is the vocabulary insertion of the I complex which consists of C+I. The I head is actually a complex of tense and number features which can be represented as in (19a). The C head does not add any phonological material because the foot of the morphosyntactic chain it is part of has already undergone VI, (17), (see Lidz and Idsardi 1998 for some proposals for how syntactic chains are interpreted). The morphophonological representation of the I complex in (19a) contains an anchor point which specifies it as a suffix (i.e. {_%} ‘follows the last segment’).

(19) VI of the I complex in (16)

a. the I-complex



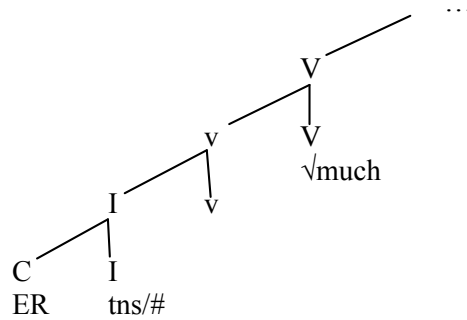
b. final morphophonological representation



The anchor point in (19a) will override the adjacency relationship between the I complex and its vP complement. This produces the representation in (19b) where the tns/# complex from (19a) follows the /h/² of √much because it is the ‘last segment’. The morphophonological representation in (19b) corresponds to the surface ER pattern of *baagilannu much-gich-ide* from (14a).

The explication of how the morphosyntactic representations in (14) and (16) undergo vocabulary insertion as part of spell-out demonstrate all of the important segmental aspects of how the morphophonological module interprets a morphosyntactic representation. Consequently, we only need to discuss the differences of the ordering of VI for the remaining two ER patterns. (20) presents the relevant chunk of morphosyntactic representation from (14b).

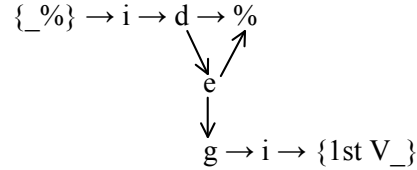
(20) ER pattern *baagilannu [muchide]-gichide*



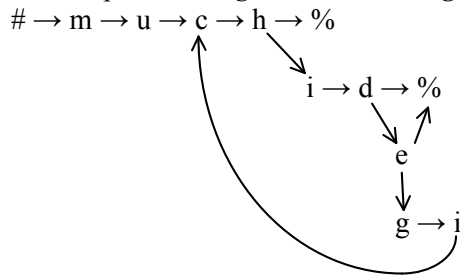
The morphosyntactic tree in (20) indicates that the C, I and v heads have all lowered to the V head as a single complex. The morphophonological result of this representation will be that the complex I head will be as in (21a) when the ER morpheme is concatenated to the tns/# structure from (19a).

(21) Morphophonological representation for (20)

a. the C+I complex



b. ER pattern *baagilannu muchide-gichide*

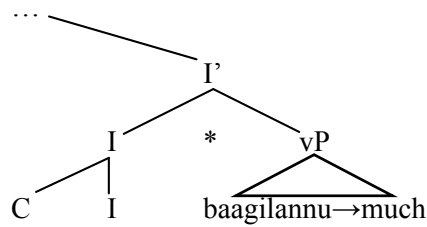


(21b) is the result of concatenating (21a) to the verb root $\sqrt{\text{much}}$. The adjacency relation between the V and DP nodes will be converted to placing the structure in (15c) before the one in (21b). This resulting representation corresponds with the ER pattern where the verb root with its tns/# suffixes repeated, (4b) *baagilannu muchide gichide*.

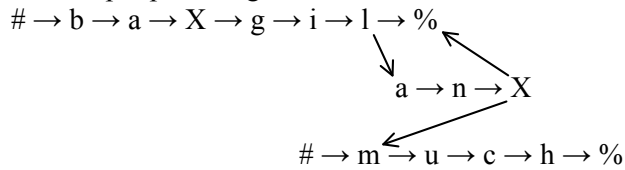
The final ER pattern which needs to be accounted for is from (14c) where the entire verb structure and its complement is reduplicated. This pattern results from the ER morpheme only lowering to the I head and no further. The important aspects of the morphosyntactic tree for this example is presented in (22a) while (22b) shows the morphophonological structure of the VP which will be spelled out when the C+I complex is spelled-out and concatenated.

(22) ER pattern *baagilannu muchide giigilannu muchide*

a. morphosyntax

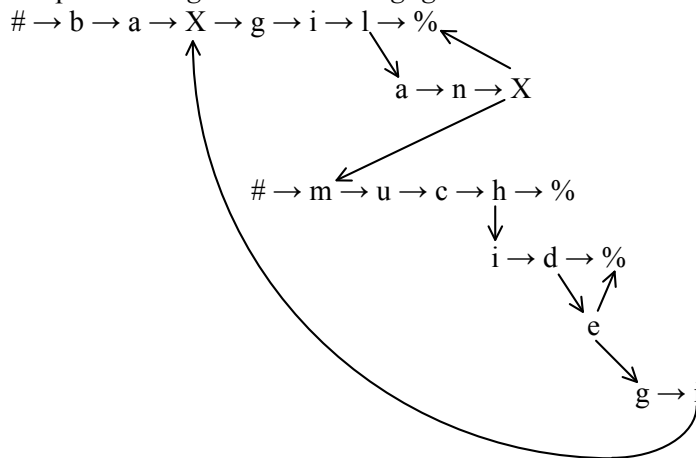


b. morphophonological structure of VP



The morphophonological structure of the C+I complex in (22a) is identical to (21a). When this structure is concatenated to the one in (22b), the structure in (23) is produced and it corresponds to the surface ER pattern of *baagilannu muchide giigilannu muchide*.

(23) ER pattern *baagilannu muchide giigilannu muchide*



To conclude this section, the operation of spell-out converts morpho-syntactic representations to morphophonological representations through

vocabulary insertion. The morphosyntax provides the order in which morphemes under go vocabulary insertion and converts adjacency relationships to precedence relationships. Specific aspects of morphophonological representations provide the basis for phonological differences between roots and affixes and between concatenative and non-concatenative morphology. The most important aspect is that four distinct morphophonological representations result from the four distinct morphosyntactic representations in (14). These morphophonological representations are interpreted by the phonology.

5.0 The phonology of ER

The phonology module converts the morphophonological representation into a fully specified and completely linearly ordered phonological representation that can be interpreted by the phonetics module. Given the morphophonological representations derived in the previous section, there are four aspects that the phonology must deal with: ‘long’ segment interpretation, the ‘Enunciative vowel’ (Bright 1972), serialization of graph to linear string and the ordering of these processes. Due to space considerations, none of these issues can be dealt with in detail. We will only discuss each in a very brief manner.

The empty X-slot used to indicate vowel length will be filled via autosegmental spreading from the preceding segment. The ‘Enunciative vowel’ is the vowel that surfaces at the end of the ACC morpheme and is inserted based on morphologically determined environments (Aronoff and Sridhar 1983). These two processes must be ordered with respect to serialization. Insertion of the enunciative vowel occurs before linearization and long segment interpretation occurs after linearization. The evidence for this ordering is based on over and normal application of the relevant processes in ER. See Idsardi and Raimy (in prep) for a full discussion of these issues.

Serialization (formally named with the overloaded term “linearization,” Raimy 1999, 2000) maps the morphophonological directed graph into a linear string. Idsardi and Shorey (2007) and McClory and Raimy (2007) provide derivational algorithms to serialize morphophonological graphs. For the purposes of this chapter, serialization will cause any segments that occur in a transitive symmetrical precedence relation to be repeated once. These transitive symmetrical precedence relations are visibly

recognizable when a morphophonological representation has a ‘loop’ in it. The morphophonological representation of the ER morpheme will always create this situation because of the anchor points involved. The first anchor point of the ER morpheme is ‘last segment’ and the second anchor point is ‘segment after the first vowel’. The ordering relationship between these two descriptions ensures that a transitive symmetrical relationship will be established because the ER morpheme states that ‘the last segment will precede the segment following the first vowel’.

The main result of section 4 was to produce different morphophonological graphs that differ as to what segments occurred in a transitive symmetrical precedence relationship (i.e. in ‘the loop’). From these different precedence graphs, serialization correctly produces the different surface patterns of ER. These serialized representations are then passed onto the phonetics module.

6.0 Temporal aspects of speech

In this chapter we have attempted to present a fairly complete example of a mapping from narrow syntax that contains no serial ordering information to a completely serialized (i.e. nonreflexive, asymmetric) representation that can be interpreted by the sensory-motor interface. Our main proposal is to unpack linearization into three separate processes which map independently necessary representations from one grammatical module into independently necessary representations of another grammatical module. Immobilization adds adjacency relations to the hierarchical structure of narrow syntax as the representation is mapped into the morphosyntax. Vocabulary insertion converts the adjacency and hierarchy structure of the morphosyntax into a precedence graph which only contains phonological material and no hierarchical relations. Serialization takes the morphophonological precedence graph and maps it into a linear string of segments which is legible by the phonetics module. Further computation occurs to convert the serialized phonetic representation into a motor-control legible representation.

Although we are sure that improvements can be made to our analysis of all the grammatical aspects of Kannada that we have presented, the overall arc of this analysis is the important aspect of this paper. The key theme to this arc is that we have been explicit about the architecture of the grammar and the representations in each module. We also assume that

there is a connection between the representation and computation in each module thus differences in modules should coincide with a difference in representation and computation.

Strict linear order is not present until the later stages of a derivation when the representation is sent to the phonetics module. Prior to this point, each grammatical module transforms the type of representation that is being computed on and the type of representation should be the source of type of explanation. Evaluation of this claim about strict linear order must be done within each module. Consequently, demonstrating the necessity of linear order in the narrow syntax, morphosyntax, morphophonology or phonology modules would be sufficient to require the present proposals to be modified. To our current knowledge though, narrow syntax does not provide any evidence of linear order nor does morphosyntax. Morphophonology provides ample evidence from autosegmental representations, geminates, infixation and root-and-template morphology which strongly suggests that phonological representations are not necessarily linear. Finally, operations like tier conflation (McCarthy 1986) provide evidence for the claim that by the end of the phonology representations must be linear.

The research program on linearization and serial order in syntax is a recent development but other areas of cognitive science have identified the problem of serial order previously. Lashley (1951:114) identifies the question of how temporally integrated behavior results or is encoded in the brain as "... both the most important and also the most neglected problem of cerebral physiology." Part of the evidence that Lashley considers when formulating this problem is different word orders in different languages. He concludes,

"The individual items of a temporal series do not in themselves have a temporal 'valence' in their associative connections with other elements. The order is imposed by some other agent." (Lashley 1951:116)

This view is congruent with Berwick and Chomsky's (forthcoming) idea that linear order is introduced as part of the externalization of language and is not a feature of the narrow syntax. The convergence of two vastly different views can be construed as independent evidence in favor of the general research program on linearization. The removal of linear order in narrow syntax provides the basis for a deeper investigation on how lan-

guage is represented in the brain. A further benefit of this research program is that by separating the narrow syntax from the externalization of language, we gain a foothold on understanding why many aphasias can disrupt the input and/or output of language but apparently leave core conceptual structure intact. It is only in an approach to linear order in grammar where different modules with corresponding representations and aspects of linear order exist that these insights into how language operates in the brain can be obtained.

Notes

- * We would like to thank Jeff Lidz and Norbert Hornstein for discussing the syntactic aspects of this talk. Paul Grobstein has also influenced the ideas on serial order in the brain present here. All mistakes of interpretation and fact are our responsibility alone. Aspects of this work were supported by a grant awarded to Eric Raimy by the Graduate School at UW-Madison supported by the Wisconsin Alumni Research Fund.
1. The digraph 'ch' in $\sqrt{\text{much}}$ 'close' is a voiceless lamino-post alveolar affricate (Sridhar 1990:293). We have separated the digraph into two segments for graphic convenience although this is not likely the most accurate phonological representation of this phone. No aspect of the present analysis is affected by this presentational simplification.
 2. See note 1 above.

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