XX. LINGUISTICS*

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RESEARCH OBJECTIVES

The ultimate objective of our research is to gain a better understanding of man’s mental capacities by studying the ways in which these capacities manifest themselves in language. Language is a particularly promising avenue because, on the one hand, it is an intellectual achievement that is accessible to all normal humans and, on the other hand, we have more detailed knowledge about language than about any other human activity involving man’s mental capacities.

In studying language it has long been traditional to deal with certain topics such as pronunciation, inflection of words, word formation, the expression of syntactic relations, word order, and so forth. Moreover, the manner in which these topics are treated has also been quite standard for a very long time. This format has on the whole proved to be quite effective for the characterization of all languages, although quite a few shortcomings have been noticed and discussed at length. It would seem plausible that the main reason for the success of the traditional format is that it was adequate to the task, and to this extent the traditional framework embodies true insights about the nature of language. Much of the effort of our group continues to be devoted to the further extension of the theoretical framework of linguistics and to the validation of particular aspects of the framework. As our work progresses it becomes ever clearer that a single framework must indeed underlie all human languages for when really understood the differences among even the most widely separate languages are relatively minor.

The preceding discussion leads quite naturally to the question, "What evidence from outside of linguistics might one adduce in favor of the hypothesis that all languages are

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constructed in accordance with a single plan, a single framework?" It seems to us that the most striking evidence in favor of the hypothesis is, on the one hand, the rapidity with which children master their mother tongue, and on the other hand, the fact that even a young child's command of his mother tongue encompasses not only phrases and utterances he has heard but also an unlimited number of phrases and utterances he has not previously encountered. To account for these two sets of facts, we must assume that in learning a language a child makes correct inferences about the structural principles that govern his language on the basis of very limited exposure to the actual sentences and utterances. In other words, we must assume that with regard to matters of language a child is uniquely capable of jumping to the correct conclusions in the overwhelming majority of instances, and it is the task of the student of language to explain how this might be possible.

A possible explanation might run as follows. Assume that the human organism is constructed so that man is capable of discovering only selected facts about language and, moreover, that he is constrained to represent his discoveries in a very specific fashion from which certain fairly far-reaching inferences about the organization of other parts of the language would follow automatically. If this assumption is accepted, the next task is to advance specific proposals concerning the devices that might be actually at play. The obvious candidate is the theoretical framework of linguistics, for while it is logically conceivable that the structure of language might be quite distinct from that of the organism that is known to possess the ability to speak, it is much more plausible that this is not the case, that the structures that appear to underlie all languages reflect quite directly features of the human mind. To the extent that this hypothesis is correct – and there is considerable empirical evidence in its favor – the study of language is rightly regarded as an effort at mapping the mysteries of the human mind.

M. Halle

A. A REVISED DIRECTIONAL THEORY OF RULE APPLICATION IN PHONOLOGY

NIH (Grant 5 TO1 HD00111-08); NIMH (Grant 2 PO1 MH13390-06)

J. T. Jensen, Margaret Stong-Jensen

This report focuses on phonological rules that propagate their effect across a string. The convention proposed by Chomsky and Halle\(^1\) for such rules is simultaneous application using star notation. This convention has been criticized recently by S. R. Anderson\(^2\) and others for being needlessly complicated when applied to fairly straightforward rules. For example, the rule of Hungarian Unrounding\(^3\) expressed using star notation is

\[(1) \quad \overset{\overline{}}{\overline{o}} \rightarrow e / \left[ \overline{\text{\text{-round}}} \right] \left( C_{\overline{o}} \overset{\overline{\overline{o}}}{\overline{\overline{o}}} \right) \overset{\overline{\overline{o}}}{\overline{\overline{o}}} C_{\overline{o}} \]

In order for such a rule to describe a propagation, the material within ( )\(^*\) must duplicate the focus or input (here \(\overset{\overline{\overline{o}}}{\overline{\overline{o}}}\)), plus elements from the nonrepeating environment (here \(C_{\overline{o}}\), such that the duplicated focus is in a position to undergo some (earlier) expansion of the rule. Anderson discusses a number of more complex examples of this type, where the duplication of material within the starred environment makes the rules quite

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unwieldy. Rules using star notation that do not conform to this constraint are formally possible. Such rules do not describe propagations, and do not seem to be possible rules of language. In this sense the simultaneous theory is too powerful. Conversely, the simultaneous theory is incapable of expressing the rule of Klamath deglottalization discussed by Kisseberth.\(^4\) The facts of Klamath can only be described by the iterative convention.

J. R. Vergnaud\(^5\) has proposed a notation using variables and a combination of conjunctive and disjunctive ordering which he claims can replace star notation. His claim is weakened, however, by examples like Hungarian Unrounding, where the simultaneous convention requires star notation to avoid stating complicated restrictions on the X variable. Rule (1) stated with the X notation is

\[
(2) \quad \partial \rightarrow e / [V \ \text{round}] X
\]

But X must be constrained to include no other round front vowel. The rule never operates over \(\ddot{u}, \dddot{u}, \text{ or } \dddot{\ddot{o}}\) (where \(\ddot{u}, \dddot{u}, \text{ and } \dddot{\ddot{o}}\) represent long versions of \(\ddot{u}, \dddot{u},\)) although it does operate over \(\ddot{o}\) if this \(\ddot{o}\) is itself converted to \(\partial\). The rule must derive (3b) from (3a):

(3)  
\[a. \ sz\ddot{o}vet + \ddot{o}t\ddot{k} + \text{h\ddot{o}z} \]
\[b. \ sz\dddot{o}vetetekhez \quad \text{'toward your (pl.) cloth'} \]

But the rule must not apply to the forms of (4), which are grammatical as they stand, to produce the corresponding forms of (5):

(4)  
\[a. \ kezelo\ddot{o}h\ddot{\ddot{o}}z \quad \text{'toward (the) operator'} \]
\[b. \ hegy\ddot{\ddot{u}}kh\ddot{\ddot{o}}z \quad \text{'toward their hill'} \]

(5)  
\[a. \ *kezel\ddot{o}\dddot{o}hez \]
\[b. \ *hegy\dddot{\ddot{u}}khez \]

To avoid the forms of (5), a restriction must be placed on X in rule (2), which can be stated as (6) using features:

(6)  
\[X \text{ contains no segment of the form } [V \ \text{round} \\{[+\text{high}] \{[+\text{long}] \}\}] \]

But both formulations (1) and (2) miss the obvious generalization that \(\partial\) unrounds only if the immediately preceding vowel is unround. The formulation that captures this generalization, and which is more natural and straightforward, is one using the iterative convention:
The iterative convention has been criticized as having excessive power because of the apparent need to specify the direction of application individually for each rule. For example, the iterative rule (8) can apply either right-to-left or left-to-right:

(8) \[ \text{[ ]} \rightarrow [+F] / [-F] C_0 \]

But a simultaneous rule can just as easily describe the same processes. For example, rule (9a) has the same effect as (8) with L-R iteration, and (9b) has the same effect as (8) with R-L iteration:

(9) a. \( \text{[ ]} \rightarrow [+F] / [-F] C_0 ([-F] C_0 [-F] C_0)^* \)

b. \( \text{[ ]} \rightarrow [+F] / [-F] C_0 \) (simultaneous)

Notice that (8) with L-R iteration produces an alternating pattern, as does (9a), while (8) with R-L iteration (and (9b)) affects every segment that is in the appropriate environment in the input string. If the input string is (10a), L-R iteration (and (9a)) produces (10b), while R-L iteration (and (9b)) produces (10c).

(10) a. \([-F] C_0 [-F] C_0 [-F] C_0 [-F] C_0 [-F] C_0 [-F] C_0\)

b. \([-F] C_0 [+F] C_0 [-F] C_0 [+F] C_0 [-F] C_0 [+F] C_0\)

c. \([-F] C_0 [+F] C_0 [+F] C_0 [+F] C_0 [+F] C_0 [+F] C_0\)

Irwin Howard made the first attempt to formulate a theory to predict the directionality of iterative rules. The cases that he dealt with are classified in Table XX-1.

Table XX-1.

<table>
<thead>
<tr>
<th>Nonalternating</th>
<th>Alternating</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Feeding</td>
<td>II Nonbleeding</td>
</tr>
<tr>
<td>Arabela Vowel-Nas.</td>
<td>Finnish Gradation</td>
</tr>
<tr>
<td>S. Agaw Vowel-Raising</td>
<td>Mandarin Tone Diss.</td>
</tr>
</tbody>
</table>

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Howard proposed the following algorithm: a rule applies in a direction from the determinant (segment causing the change) toward the focus (segment undergoing the change). If the determinant is to the right of the focus, the rule applies right-to-left, as in (11a), and vice versa (11b):

(11) a. South Agaw Vowel Raising

\[
\begin{align*}
\text{[+syll]} & \rightarrow \text{[+high]} / \quad \text{Co} \quad \text{[+high]} \\
\text{[low]} & \text{ (R-L iterative)}
\end{align*}
\]

b. Arabela Vowel Nasalization

\[
\begin{align*}
\text{[-cons]} & \rightarrow \text{[+nas]} / \quad \text{[+nas]} \quad \text{ (L-R iterative)}
\end{align*}
\]

Unfortunately for Howard's theory, many iterative rules apply in the reverse direction, e.g., Finnish Gradation (simplified in 12 to represent degemination only):

(12) \[ \text{C}_i \text{C}_i \rightarrow \text{C}_i / \quad \text{[+syll]} \quad \text{[\#]} \quad \text{str \# 1} \quad \text{(j) [+]syll\{[+]syll\}} \]

\text{ (L-R iterative)}

Howard proposed that these counterexamples to his directional theory (in fact, all cases under II) apply simultaneously (as in the older theory) rather than iteratively. Not only does this weaken his theory considerably, it renders it vacuous. It is impossible to falsify his claim, since any propagating rule fits into one of the two categories.

We propose Principle A to account for all the cases in Table XX-1.

PRINCIPLE A: Propagating rules produce a pattern that is alternating or nonalternating. Segmental rules and tone rules are nonalternating; they apply to produce the maximal effect, in feeding or nonbleeding order. Stress rules and glide rules are of the former type; they apply in bleeding order.

It is possible to account for rules of types I and II by the formal principle that rules apply in unmarked order to produce the maximal effect, i.e., they are feeding or nonbleeding. This principle was proposed by Kiparsky to predict ordering of pairs of rules. We extend it to predict directionality of segmental iterative rules. Although Howard's algorithm correctly predicts the direction of application of rules of type I, Principle A claims that this direction is required on independent grounds that also account for the directionality of rules of type II. For example, Arabela vowel nasalization, (11b), applies to (13a) to derive (13b):

(13) a. /'nuwaʔ/

b. [ʼnũw̃aʔ]
If the rule applied in the reverse direction (right-to-left), it would be nonfeeding, and derive (14) instead of (13b):

(14) $\#[\tilde{n}\nuwa?]$

(14) is opaque with respect to the rule, since there is a segment in the environment to undergo nasalization that has not undergone it.

Rules of type II, which are counterexamples to Howard's theory, must apply maximally for a different functional reason. Consider Finnish Gradation (12). Given an input with several geminates, as (15a), the rule applies to degeminate all but the last of these, i.e., it produces a nonalternating pattern (15b).

(15) a. rokko + tt + utta + tte
   b. rokotutatte 'you (pl.) are having (someone) inoculated'

As Paul Kiparsky has pointed out to us, the surface morphological alternations of Finnish would be unduly complicated if degemination applied in the opposite direction, right-to-left. Consider forms derived from the root rokko:

(16) Underlying | L-R application | R-L application
   a. rokko     |               | rokottava
   b. rokko + tta + va | rokottava | rokottava
   c. rokko + tt + utta + va | rokotuttava | *rokotuttava
   d. rokko + tt + utta + tte | rokotutatte | *rokotutatte

R-L application in (16b) degeminites the kk of the root, producing a derived root roko-. But R-L application in (16c) leaves the geminate in the root, giving a derived root rokko-. And in (16d), R-L application produces a derived root roko-, like (16b). Note furthermore that the presence of kk in the derived root depends on the number of suffixes with geminate stops that are added. If an odd number of such suffixes is added, the root is roko, as in (16b) and (16d). If an even number is added, the root is rokko, as in (16c). Notice that the suffixes tt and utta are also changed when another geminate-stop suffix is added, as in (16d). With R-L application, not only do the shapes of the derived root and suffixes change with each new suffix combination, but furthermore the pattern depends on the number of suffixes added to the root. On the other hand, L-R application, which gives grammatical forms, preserves the derived shapes of root and suffixes regardless of the number of suffixes added. The nonbleeding direction is necessary to maintain morphological regularity in the paradigm.

Tone rules are a second kind of type II rule, which apply in the nonbleeding
direction, contrary to Howard's theory. For example, there is a tonal sandhi rule in Mandarin Chinese that changes tone 3 to tone 2 before another tone 3:

(17) 3 3 → 2 3

In a longer sequence of 3 tones, it applies as follows:

(18) 3 3 3 3 → 2 2 2 3

The rule can be written as

(19) [3 tone] → [2 tone] / _____ [3 tone]

To produce a nonalternating pattern, the rule operates left-to-right, in the nonbleeding direction. Notice that this tone rule produces the same effect as the segmental rules of types I and II, i.e., a nonalternating pattern. Halle and Stevens have proposed that tone in vowels and voicing in obstruents are governed by the same distinctive features, stiff vocal cords and slack vocal cords. It is thus natural that tonal sandhi rules should operate in the same manner as voicing assimilation rules, to produce nonalternating patterns.

In rules of type III, a different principle operates namely, that sequences of stressed vowels and sequences of glides do not occur in languages. The former dis-similate into stressed-unstressed sequences, the latter tend to alternate with vowels. Languages with glide formation rules (or vocalization rules that operate on a sequence of glides, as in Indo-European) do not change all vowels in a sequence to glides (or all glides to vowels) but instead change only alternate vowels to glides.

Howard considers several rules of alternating stress, including the well-known rule of Southern Paiute,

(20) [+syll] → [+stress] / V C_o _____

This rule applies left-to-right and produces an alternating pattern. Given (21a) as an input string, rule (20) produces the output string (21b):

(21) a. V V V V V V V V V
    b. V V V V V V V V V

Similarly, rules of glide formation operate to produce alternating patterns; for example, Eastern Ojibwa Glide Formation given as

(22) [+syll] → [−syll] / _____ [+syll]

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Given the input (23a), the rule produces (23b)

(23)  

a. /eninoak/  
b. [eniniwak] 'men'

by applying right-to-left. The reverse direction of application (or simultaneous application) would change the whole sequence of non-low vowels to glides, thereby producing the ungrammatical form *eninywak.

There are no convincing examples of rules of type IV. Howard noted two apparent cases, which he then reanalyzed. Since a nonfeeding assimilation would produce opaque surface forms (such as (14)), we predict that no such rules exist, or that, if they do, the resulting opacity is destroyed by later rules.

Principle A makes the very strong claim that the directionality of propagating rules can be predicted from their effect. In fact, we can make the stronger claim that all rules are iterative, since for rules that do not propagate directionality does not matter. For example, a rule that palatalizes a consonant before a front vowel may be considered iterative, although it does not propagate its effect.

The generalization made by Principle A is not expressible either in the excessively formal simultaneous theory or in Howard's partially directional theory. The variable notation proposed for simultaneous rules could formally distinguish alternating rules from nonalternating rules by rather specific and complex restrictions on disjunctive and conjunctive ordering. But these restrictions have no independent motivation in phonology, as have the notions of feeding and bleeding, on which Principle A is based. Furthermore, for rules that require star notation (e.g., Hungarian Unrounding), a restriction must be added to distinguish alternating from nonalternating rules in terms of star notation, which will be equally complex and ad hoc. Since Howard's theory allows both simultaneous and iterative rules, it is impossible for him to make any unified generalization.

The increased explanatory power of the revised theory constitutes a decisive case for iterative application. It gives sufficient justification for eliminating simultaneous application from phonology. Such a move not only relieves the theory of a very powerful device; it also avoids the extensions of conjunctive and disjunctive ordering that are needed to make simultaneous rules work.

The authors have benefited from extensive discussions with Morris Halle and Paul Kiparsky, who are not responsible for errors, omissions, or inconsistencies in this report.
References


B. CLAUSE STRUCTURE AND THE PERCEPTUAL ANALYSIS OF SENTENCES

NIH (Grant 5 TO1 HD00111-08); NIMH (Grant 2 PO1 MH13390-06)

Judith R. Kornfeld

The results of several experiments suggest that the clause is a fundamental unit of sentence perception.¹⁻⁴ According to these studies, the position of the clause boundary determines how a sentence is first segmented and represented in the mind of the listener. The clause boundary is not, however, the only syntactic variable that could affect early processing. Formal properties between clauses such as dominance in deep and surface structures might also influence the way in which a sentence is first analyzed. If so, the distinction between main and subordinate clauses should be perceptually relevant, since it is reflected by the dominance of one clause with respect to another in tree structures.

If clause boundaries and/or dominance properties do have effects on early sentence analysis, they should show up on a perceptual task. We tested this claim in an
experiment using the probe-latency technique because this method is known to reveal
effects of grammatical structure. The paradigm itself required a subject to listen
to a sentence, which was immediately followed by a word, called the "probe." The sub-
ject had to decide whether this word occurred in the sentence just presented, and indi-
cate his decision by pressing the lever of a two-position key. Reaction Time (RT) was
measured as the interval between presentation of the probe and the subject's response.

Material for the study included 36 sets of test sentences of the following type:

(1) \[ \text{SUBORDINATE} \ X \ , \ \text{MAIN} \] After you read the fine print on the LEASE, check the
tax clause carefully.

(2) \[ \text{SUBORDINATE} \ , \ X \ \text{MAIN} \] After you have read the fine print, the LEASE should
be checked for tax clauses.

(3) \[ \text{MAIN} \ X \ , \ \text{SUBORDINATE} \] You should read all the fine print on the LEASE, after
you've checked the tax clause.

(4) \[ \text{MAIN} \ , \ X \ \text{SUBORDINATE} \] You should read the fine print, after the LEASE has
been checked for tax clauses.

(\text{where } "X" \text{ marks the position of the probed word in each sentence})

All sentence material was read by an adult male speaker who spoke with conversational
intonation and minimized pauses at clause breaks. The sentences were recorded on
one track of a stimulus tape; on the second track a noise burst was recorded at the
end of each sentence in order to signal presentation of the probe word. Slides of the
probe words were prepared for each sentence.

Forty-eight M.I.T. undergraduates, all of whom were native speakers of American
English, took part in the experiment. Each S was tested individually in a semianechoic
chamber, which was equipped with headphones, a rear projection screen, and a tele-
graph key.

1. Experiment - Data and Results

Each subject's RT to every sentence was recorded in milliseconds, and used in
a two-way analysis of variance. Probe position and clause order were the major vari-
ables, and subjects by replications counted as the error term. In this design, the total
variance in the data was estimated by three factors:

\[ \text{row effect} + \text{column effect} + \text{their interaction} \]
\[ \text{due to surface} \quad \text{due to clause order} \quad \text{due to kind of clause} \]
The analysis revealed that probes from the first clause were recognized faster than probes from the second clause. \( F = 10.828, p < .003, \text{df}=1/47 \). Thus, the surface boundary effect was highly significant, but the dominance effect was not. \( \text{For clause order, } F = .773; \text{df}=1/47; \text{and for the interaction of probe position x kind of clause, } F = .201, \text{df}=1/47 \). Several post hoc tests indicated that a materials effect was present, however, and it may have been large enough to mask the dominance effect.\(^5\)

2. Conclusions

This experiment shows that the position of the clause boundary crucially affects the immediate perception of a sentence. In this study we have replicated an earlier test by Caplan,\(^3\) who found the boundary effect for the single clause order \([\text{subordinate}]\ldots [\text{main}]\). Our results show that the effect is independent of clause order. The effect may also be independent of dominance properties, since the main-subordinate variable did not cause significant differences in RT. The post hoc tests, however, did reveal a materials effect, so it is still possible that the dominance effect was only masked.

These findings are compatible with the view that sentences are analyzed clause-by-clause; i.e., when a single clause is perceived, it is analyzed and represented in a structural description. This representation, or its trace, is still accessible when the sentence has just ended. The dominance properties of sentences may also be represented in the mind of the listener, but more tests with revised material are needed to establish this claim.

References and Footnotes

5. One test required three psycholinguists to rate each sentence by the following criteria:

   Is the first clause in versions (a) and (b) clearly subordinate to the second clause, both in syntactic construction and semantic interpretation?
   Is the subordinating marker the same in all four versions – and is the meaning of this adverbial constant throughout?
   Is the lexical material nearly the same across construction types?
   Are all four sentences in each set equally natural?

   Judges worked independently, and then pooled their results. Out of the 36 test
sentences, 16 were selected as best, 11 as worst, and 9 somewhere in between. Judges agreed unanimously about all but 2 sentences.

RT scores were collected from all subjects responding to each version of every sentence; these scores were then used as data for an ANOVA with sentences as the error term. Two analyses were done (with sentences as the repeated measure): one on the 16 best sentences, and one on the remaining 20. (Henceforth, the best sentences will be referred to as "good" ones; the remaining 20 will be called "bad" ones.)

When the "best" sentences were analyzed, there was a trend for the dominance effect, although it did not reach significance. (For clause order ([main]...[subordinate]) or ([subordinate]...[main]), F = .456, df = 1/15; and for the interaction of probe position by kind of clause, F = .881, df = 1/15). This result suggests that a materials effect obscured the dominance effect in the experiment.

C. FORMAL PROPERTIES OF LEXICAL DERIVATIONS

NIH (Grant 5 TO1 HD00111-08); NIMH (Grant 2 PO1 MH13390-06)

J. R. Vergnaud

The mechanism of transformations has been traditionally associated with the syntactic component of the grammar. In this report we shall show that it can account for certain general properties of relations among dictionary entries. For that matter it can be incorporated into a theory of the lexicon such as Halle\textsuperscript{1} has described.

Our proposal requires that we revise slightly the formalism proposed by Chomsky\textsuperscript{2} for the statement of subcategorization and selectional restriction frames. We shall assume that each verb or adjective is provided with a frame wherein all nodes relevant for contextual features appear, as the PS rules generate them. For each node, the frame will indicate whether the verb or the adjective is positively specified for this node and, if so, what the selectional restrictions are that correspond to the node. Thus the contextual frame of an intransitive verb will include

\begin{equation}
\ldots \text{NP}[[-\text{unit}]]\text{NP} \ldots
\end{equation}

where [\text{-unit}] stands for "\emptyset". The contextual frame of a transitive verb will include

\begin{equation}
\ldots \text{NP}[+\text{unit}]
\begin{array}{c}
\alpha F \\
\beta G \\
\vdots
\end{array}
\text{NP}
\end{equation}

where [\text{F}], [\text{G}], etc. are selectional restriction features. Within this framework, the dummy symbol $\Delta$ stands for the feature [+unit] without any extra selectional specification.
To give a concrete example, frighten will have the following contextual frame (see Chomsky\(^3\)):

\[
\begin{array}{c}
\hspace{1cm}
\end{array}
\]

Two adjacent bracketings in such a frame as (3) have to correspond to sister nodes. Thus the first NP in (3) has to correspond to the subject. A redundancy rule will account for the feature [+unit] in this NP: it will specify that every verb or predicative adjective has a subject. The frame in (3) must be read line by line. The first line provides the subcategorization frame

\[
\begin{array}{c}
[+\text{abstract}] \quad [+\text{animate}] \\
\cdot \quad \cdot \\
\cdot \quad \cdot
\end{array}
\]

The second line provides one of the selectional restrictions:

\[
[+\text{abstract}] \quad [+\text{animate}]
\]

and so on.\(^4\)

Note that this formalism distinguishes clearly between subcategorization features and selectional features: it is no less adequate than Chomsky\(^2\) in providing a basis for the account of the syntactic and semantic differences between those two kinds of features.

Since the contextual frames are strings of elements, they can be inputs to (and outputs of) transformations. We shall give an example of a transformational derivation involving contextual frames. Let \(T_1\) be the transformation (call it lexical transformation):

\[
T_1 \quad \begin{array}{c}
\text{NP} \\
1 \\
2 \\
3
\end{array} \rightarrow \begin{array}{c}
\text{NP} \\
2 \\
\emptyset
\end{array}
\]

\(T_1\) will operate on a string of the form

\[
\begin{array}{c}
\text{NP}^{[\mu]} \text{NP}^{[\nu]} \text{VP}^{[\cdot]} \quad \text{NP}^{[\mu]} \text{NP}^{[\nu]} \quad \text{VP}^{[\cdot]}
\end{array}
\]

to produce a string of the form

\[
\begin{array}{c}
\text{NP}^{[\mu]} \text{NP}^{[\nu]} \text{VP}^{[\cdot]} \quad \text{NP}^{[-\text{unit}]} \text{NP}^{[\mu]} \text{NP}^{[\nu]} \quad \text{VP}^{[\cdot]}
\end{array}
\]

Clearly, \(T_1\) is the lexical equivalent of the syntactic transformation of Object Preposing. Another transformation which it will be useful to consider is
where \( X \) is a variable. Actually \( T_2 \) stands for a set of transformations; to each value of the preposition in \( T_2 \) a specific transformation is associated. If, for instance, \( \text{prep} \) is \( \text{by} \). \( T_2 \) will operate on a string of the form:

\[
\text{NP}[ \mu ] \text{NP VP}[ \ X \text{by} \ NP[ \nu ] \text{NP} \ldots ] \text{VP} \ldots
\]

to produce a string of the form

\[
\text{NP}[[-\text{unit}]] \text{NP VP}[ \ X \text{by} \ NP[ \mu ] \text{NP} \ldots ] \text{VP} \ldots
\]

Clearly, this version of \( T_2 \), let it be \( T_2 (\text{by}) \), is the lexical equivalent of the syntactic transformation of Agent Postposing.

Assuming Halle's theory of the lexicon, we shall consider such transformations as \( T_1 \) or \( T_2 \) as elements of the lexicon. We assume, moreover, that for each lexical transformation \( T \), the lexicon contains the inverse of \( T \), written \( T^{-1} \). Thus the lexicon contains \( T_1^{-1} \) and \( T_2^{-1} \):

\[
T_1^{-1} \quad \text{NP} \rightarrow \emptyset \quad 2 \quad 1
\]
\[
T_2^{-1} \quad \text{NP} \rightarrow \emptyset \quad X \quad \text{prep} \quad \text{NP} \rightarrow \emptyset \quad 2 \quad 3 \quad 4
\]

We have now presented informally a device that can describe certain types of relations between contextual frames. It remains to consider the precise status and function of this device within the grammar.

Following Halle, we shall treat the lexicon as a list of morphemes and of derivational rules and related mechanisms. An example of a derivational rule is

\[
\phi = \{ V[\text{Adj}]+en \}_{V}, S_{\phi}, \Sigma_{\phi} \}
\]

This rule associates, \( \text{e.g., black} \) and \( \text{blacken} \); \( S_{\phi} \) and \( \Sigma_{\phi} \) represent, respectively, the regular syntactic and semantic modification introduced by \( \phi \). Other derivational rules are:

\[
\Psi = \{ A[\text{Verb}]+able \}_{A}, S_{\Psi}, \Sigma_{\Psi} \}
\]
\[
\theta = \{ A[\text{Verb}]+ion \}_{N}, S_{\theta}, \Sigma_{\theta} \}
\]

\( \Psi \) relates, \( \text{e.g., read} \) and \( \text{readable} \) and \( \theta \), \( \text{e.g., destroy} \) and \( \text{destruction} \). We shall not
give here the underlying phonological representations of the suffixes corresponding to \( \psi \) and \( \theta \) (nor do we state the fact, for instance, that the suffix \( \text{ion} \) is often preceded by the affix \( \text{At} \) (see Chomsky and Halle\(^5\)). The bracketed structures showing up in the representations of \( \phi \), \( \psi \), and \( \theta \) have nothing to do with the internal bracketings of the words that are the outputs of the rules; they simply describe the morphological and phonological effects of \( \phi \), \( \psi \), and \( \theta \). Borrowing the term from Dell,\(^6\) we call such rules \( \phi \), \( \psi \), and \( \theta \) transpositions. Assuming a dictionary (the output of the filter, see Halle\(^1\)) that is a list of all words of the language, with their phonological, morphological, syntactic and semantic features, we shall now define a function \emph{distance} in the dictionary in the following manner: Let \( N \) be the total number of features in the universal set of features, let \( n \) be the number of features that an element \( y \) of the dictionary has in common with another element \( x \) of the dictionary, then the distance between \( x \) and \( y \) will be

\[
(11) \quad d(x, y) = 1 - \frac{n}{N}
\]

No doubt, this is a very crude approximation, which presumably will reveal itself inadequate and at least will require numerous and complex refinements. It will be amply sufficient for our purpose, however, which is to illustrate the functioning of the lexical transformations. We call \( d(x, y) \) the absolute distance between \( x \) and \( y \). It is immediately obvious that the absolute distance cannot describe adequately the relatedness of dictionary entries; it is the intuition of the speaker that \emph{black} and \emph{blacken} are no less strongly related than \emph{destroy} and \emph{destruction}; however, the absolute distance in the former case is much greater than in the latter, essentially because of the modifications in the contextual frame introduced by \( \phi \). It seems clear, though, that "distance" remains the natural and correct notion in all of these cases. It appears that the function \emph{distance} has simply to be made dependent on the particular transposition under consideration. Consider \( \phi \), for instance. One can very naturally define a "distance modulo \( \phi \" (written \( d_{\phi} \)):

\[
(12) \quad d_{\phi}(x, y) = 1 - \frac{n_{\phi}}{N}
\]

where \( n_{\phi} \) is the number of features of \( y \) which can be deduced from features of \( x \) through the operation of \( \phi \), and \( N \) is as defined in (11). The distance \( d_{\phi} \) will be defined over any couple of entries \((x, y)\) such that one of the two entries is marked \([+\phi]\). In the dictionary (and in the lexicon) \emph{black} will be marked \([+\phi]\). Of course, the problem remains of determining \( n_{\phi} \). We are not in a position to solve this problem here. We simply point out that it is precisely at this stage that lexical transformations intervene and we shall describe how they can be used to compute, partially at least, the
number N - n. Here again the mechanism is very classical and natural. In the lexicon, \( \phi \) will be marked \([+T^{-1}]\) (the feature \([+T^{-1}]\) being an element of \( S_\phi \)). Then, in any doublet \((x, y)\), where \( x \) is \([+\phi]\), no contextual feature of \( y \) that can be deduced from a contextual feature of \( x \) by the application of \( T_1^{-1} \) will count in the distance modulo \( \phi \) between \( x \) and \( y \). Consider the pair \((\text{black}, \text{blacken})\). If \( \text{black} \) has the contextual frame

\[
\begin{array}{c}
\text{NP} \\
\text{VP}
\end{array}
\begin{array}{c}
\begin{array}{c}
[+\text{unit}] \\
\alpha F \\
\beta G \\
\gamma H
\end{array} \\
\vdots \\
\text{NP}
\end{array}
\begin{array}{c}
\begin{array}{c}
[+] \\
\text{NP}[-\text{unit}] \\
\ldots
\end{array} \\
\ldots
\end{array}
\]

and \( \text{blacken} \) has the contextual frame

\[
\begin{array}{c}
\text{NP} \\
\text{VP}
\end{array}
\begin{array}{c}
\begin{array}{c}
[+\text{unit}] \\
\alpha F \\
\beta G \\
-\gamma H
\end{array} \\
\vdots \\
\text{NP}
\end{array}
\begin{array}{c}
\begin{array}{c}
[+] \\
\text{NP}[-\text{unit}] \\
\ldots
\end{array} \\
\ldots
\end{array}
\]

the feature "--- \( \text{NP}[+\text{unit}]\text{NP} " in (14) will count for 0 in the distance modulo \( \phi \) between \( \text{black} \) and \( \text{blacken} \) because it is part of the output of \( T_1^{-1} \) operating on

\[
\text{NP}[+\text{unit}]\text{NP} \text{VP}[--- \ldots
\]

Similarly, the features "--- \( \alpha F \)" and "--- \( \beta G \)" will count for 0. On the other hand, "--- \( -\gamma H \)" is not deducible from \( \gamma H \), and hence will be counted. Clearly, certain selectional restrictions imposed by the subject of \( \text{blacken} \), as well as the strict subcategorization \( \text{NP}[+\text{unit}]\text{NP} \text{VP}[--- \ldots \) are also deducible from the syntactic properties of \( \phi \). That implies that to each feature \( i \) we must associate an insertion transformation \( u_i \), and \( \phi \) must be specified positively or negatively for each feature \( [u_i] \). We shall not go into the details of such a system.

Having described the role of the lexical transformations, we now explore some of the implications of the formalism. Consider again the transposition \( \Psi \), which we repeat here

\[
\Psi = \{ A[\text{Verb}]\text{able}1_A, S_\Psi, \Sigma_\Psi \}
\]

In the pair \((\text{read}, \text{readable})\) the same selectional restrictions are imposed by the object
of read and the subject of readable. Moreover, readable has no direct object; clearly, $S_\Psi$ contains the feature $[+T_1]$. We note that readable has an optional complement with the preposition for which imposes the same selectional restrictions as the subject of read:

(16) This book is readable for most students.

This indicates that $S_\Psi$ contains the feature $[\alpha T_2 (for)]$, where $\alpha$ is either $+$ or $-$. Suppose $\alpha = +$. It is obvious that $T_2$ has to precede $T_1$. If $T_1$ preceded $T_2$, we could not generate an adequate frame for the evaluation of the distance. Thus it appears that lexical transformations, like syntactic transformations, are ordered.

Besides being specified for two distinct transformations, $\Psi$ has other remarkable properties. We observe that in order to enter the derivation $\Psi$ a form has to meet the structural description of $T_1$, i.e., has to be a transitive verb. In other words, there is a rule:

$$ [+\Psi] \rightarrow \text{NP} [+\text{unit}] \text{NP} $$

Presumably, this could be described as a consequence of the fact that $\Psi = [+T_1]$. There are a few exceptions to this rule. A first class of exceptions is constituted by such pairs as (perish, perishable) or (incline, inclinable ("having a mental bent or tendency in a certain direction")), where the verbs are intransitive. The strict subcategorization and selectional restriction frames of the verbs are identical to those of the adjectives derived from them. Strictly speaking, the adjectives cannot be considered as derived from the verbs through the application of $\Psi$. It is clear, though, that the derivation involved has strong similarities with $\Psi$. There is a very straightforward way to formalize this intuition. Let us denote $^*w$ the product of applications (if $f(x)$ is the result of $f$ applying to $x$, the result of $g \circ f$ applying to $x$ is $g(f(x))$). Considering the lexical transformations to be degenerate transpositions, with no phonological or morphological correlates, we mark perish and incline

$$ [+\Psi \circ T_1^{-1}] $$

In other words, the degenerate transposition $T_1^{-1}$ will apply first to a form like perish to make its contextual frame fit the structural description of $\Psi$: the distance between perish and perishable is defined modulo $\Psi \circ T_1^{-1}$. Note that, stricto sensu, degenerate transpositions are different objects from lexical transformations; for instance, they might be factored in a product in a different order from the one that is allowed for lexical transformations. Nevertheless, because of their formal similarities, we shall identify the two sets of objects. It is clear that the feature $[+\Psi \circ T_1^{-1}]$ should be
considered, in some sense, more costly than the feature $[+\psi]$. At this point we have no way to account for this difference. Presumably, also, heavy restrictions should be placed on the use of degenerate transpositions. A natural restriction suggesting itself immediately is the following:

(17) In a product of transpositions, the leftmost factor must be nondegenerate.

Observe that (17) has an interesting consequence. It predicts that there can be no derivation $x \rightarrow y = x+\text{able}$, where $x$ is a transitive verb, $y$ an adjective, and $x$ and $y$ have the same contextual frames. Such a derivation would require $x$ to be marked $[+T_2^{-1} \circ T_1^{-1} \circ \psi]$ and would clearly violate principle (17). To the extent to which one can have intuitions about lexical derivations, such a prediction seems to be borne out by the facts.

We turn now to another class of exceptions to $\psi$, namely the class containing such pairs as $(\text{ski}, \text{skiable})$ and $(\text{swim}, \text{swimmable})$. In such pairs the place complement becomes the subject of the derived adjective. In this case, we are led to posit the transformation:

$$T_3 \rightarrow \text{NP prep NP} \rightarrow 1 \ 2 \ 3 \ 4 \ \emptyset \ \emptyset$$

and to mark $\text{ski}$ and $\text{swim} \ [+\psi \circ T_3]$. This is essentially the approach adopted by Dell.

The notion of degenerate transposition has applications elsewhere in the lexicon. Consider, for instance, a verb such as $\text{open}$ which, as J. Bowers has shown, enters 3 different contextual frames:

$$\text{(18) open}_1 \quad \text{NP} \begin{bmatrix} \Delta \\ \mu \end{bmatrix} \text{NP} \begin{bmatrix} \Delta \\ \nu \end{bmatrix} \text{VPL} \text{NP} \begin{bmatrix} \Delta \\ \pi \end{bmatrix} \text{NP} \text{VP}$$

as in: John opened the door with a key

$$\text{open}_2 \quad \text{NP} \begin{bmatrix} \Delta \\ \nu \end{bmatrix} \text{NP} \begin{bmatrix} \Delta \\ \mu \end{bmatrix} \text{VPL} \text{NP} \begin{bmatrix} \Delta \end{bmatrix} \text{NP} \text{VP}$$

as in: the door opened with a key

$$\text{open}_3 \quad \text{NP} \begin{bmatrix} \Delta \\ \pi \end{bmatrix} \text{NP} \begin{bmatrix} \Delta \\ \nu \end{bmatrix} \text{VPL} \text{NP} \begin{bmatrix} \Delta \end{bmatrix} \text{NP} \text{VP}$$

as in: the key opened the door

where $\mu$, $\nu$, and $\pi$ are matrices of selectional features. In order to account for the properties of $\text{open}$ and of other similar items, we first define a set of canceling transformations:
Each $e_j$ replaces a particular element in the contextual frame by [−unit]. It is easy to see that the distance between open$_1$ and open$_2$ is 0 modulo $T_1^{-1}e_1$, and that the distance between open$_3$ and open$_1$ is 0 modulo $T_2^{-1}(with)e_1$. Thus, we shall mark open$_1$: [+T$_1^{-1}e_1$, [+T$_2^{-1}e_1$. The products of transpositions above violate principle (17). But the class of cases in which such violations are observed is easy to characterize: each member of the class of exceptions is a product of transpositions containing $e_j$ as a factor for some $j$. Let us call this distinguished set of products the kernel of the set of all transpositions. We can restate (17):

\[(21)\text{ In a product of transpositions that does not belong to the kernel, the leftmost factor must be nondegenerate.}\]

Observe that the kernel will account, among other things, for the relation between members of such pairs as (eat$_1$ (transitive), eat$_2$ (intransitive)): eat$_1$ is marked [+e$_2$] and the distance between eat$_1$ and eat$_2$ is 0 modulo e$_2$.

I would like to thank Morris Halle and Elisabeth Selkirk for their comments and criticisms.

References and Footnotes

3. Ibid., p. 165.
4. Clearly the selectional restrictions are imposed not by the NP as a whole but by the head of the NP. We shall not deal with this problem here.
7. Obviously, very heavy restrictions must be put on the $u_1$. They might conceivably be restricted to the subject position. In any event, they should not be allowed to reintroduce a direct object where it has been removed by $T_1$ (as in 驺); otherwise, the whole system would be reduced to vacuity.
1. Introduction

In several recent papers Kisseberth has argued that to account for the morphophonemics and segmental phonology of Klamath, rules must apply cyclically. The analysis presented by Kisseberth relies on global rules (see Lakoff), and necessitates violation of the principle of strict cyclicity (see Kean). In this report I shall show that while the data from Klamath does support cyclical rule application, it does not require the postulation of global rules and it offers support for the principle of strict cyclicity.

2. Vowel Deletion and Vowel Reduction

In Klamath there is a series of "reduplicative" prefixes which consist of a full or partial copy of the adjacent open syllable to the right, the vocalic element of the prefix always being a short copy of the vowel of the immediately succeeding syllable. For example, consider the following items:

(1)

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Meaning</th>
<th>Causative 1</th>
<th>Causative 2</th>
<th>Reflexive</th>
<th>Distributive</th>
</tr>
</thead>
<tbody>
<tr>
<td>cwe:ka</td>
<td>'is tough'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lo:pa</td>
<td>'eats soup'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pe:nhi</td>
<td>'is naked'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ci:ya</td>
<td>'stays'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>twa:qa</td>
<td>'smears'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plo:qa</td>
<td>'smear pitch on someone’s head'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to:ka</td>
<td>'hair falls out'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lo:la</td>
<td>'comes apart'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pe:wa</td>
<td>'bathes'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ma:s?a</td>
<td>'is sick'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I shall not go into the morphological processes involved in the formation of these prefixes, but I shall assume that the morphology yields strings that are fully specified phonologically, such as those in (2).

(2)

\[
\text{[# sne [# cwe:k + a #] #]}
\]
\[
\text{[# hes [# [# pe:nhi #] #]}
\]
\[
\text{[# sa [# twa:q + a #] #]}
\]
\[
\text{[# po [# to:k + a #] #]}
\]
\[
\text{[# ma [# ma:s? + a #] #]}
\]
That the internal structure of the items in (2) is necessary is a result of the fact that phonological rules apply cyclically. Regardless of any argument for the cycle, there is prima facie evidence for this structure; \( \text{cwe:ka} \) is, itself, a well-formed word; therefore, there must be a structure \( [\# \text{cwe:} \text{k} + \text{a} \#] \). Without evidence to the contrary, it would be an unwarranted assumption to suggest that this structure does not exist in the underlying structure of the prefixed form \( \text{sne\text{cwe:}ka} \).

When a reduplicative prefix precedes an open syllable with a short vowel, the vowel of that syllable deletes.

(3) \( \text{paga} \) 'smokes' \( \text{snapga} \) (causative<sub>1</sub>)
\( \text{ntopa} \) 'spoils' \( \text{snontpa} \) (causative<sub>1</sub>)
\( \text{toqa} \) 'is scared' \( \text{hostqa} \) (causative<sub>2</sub>)
\( \text{itoqa} \) 'thumps' \( \text{soltqa} \) (reflexive)
\( \text{delo:ga} \) 'attacks' \( \text{sedlo:ga} \) (reflexive)
\( \text{kaca} \) 'cut off the head' \( \text{pakca} \) 'pull off someone's head'
\( \text{teka} \) 'be in pieces' \( \text{petka} \) 'pull off bit by bit'
\( \text{kaca} \) 'cut off the head' \( \text{gwakca} \) 'bite off the head'
\( \text{tita} \) 'open a bulbous object' \( \text{gwatta} \) 'bite open a bulbous object'
\( \text{qniya} \) 'has an erection' \( \text{qniqnya} \) (distributive)
\( \text{paga} \) 'barks' \( \text{papga} \) (distributive)

The data in (3) suggest that there is a rule of vowel deletion:

(4) \( \nu \rightarrow \emptyset / [\# \text{C}_1 \text{V} \text{C}_0 \# \text{C}_1 \text{C} \text{V} \text{X} \#\#] \)

When a reduplicative prefix precedes a closed syllable with a short vowel, the vowel of that syllable does not delete but rather undergoes reduction.<sup>10</sup>

(5) \( \text{wejli} \) 'lisps' \( \text{snewa} \text{jli} \) (causative<sub>1</sub>)
\( \text{qlin} \) 'choke' \( \text{sniq\text{e}n} \) (causative<sub>2</sub>)
\( \text{bonwa} \) 'drinks' \( \text{hos\text{e}nwa} \) (causative<sub>2</sub>)
\( \text{metgal} \) 'carries a pack' \( \text{hes\text{e}mtgal} \) (causative<sub>2</sub>)
\( \text{katsga} \) 'tooth falls out' \( \text{pakatsga} \) 'pull someone's tooth out'
\( \text{qsos} \) 'sprain' \( \text{poq\text{e}sli:na} \) 'sprain by pulling'
\( \text{qlin} \) 'choke' \( \text{qliq\text{e}n} \) (distributive)
\( \text{pcin} \) 'twist' \( \text{pcip\text{e}n} \) (distributive)

Based on (5) a rule of vowel reduction such as (6) can be postulated.

(6) \( \nu \rightarrow \emptyset / [\# \text{C}_1 \text{V} \text{C}_0 \# \text{C}_1 \text{C} \text{C} \text{X} \#\#] \)

Vowel Deletion (4) and Vowel Reduction (6) are unorderable because their environments are complementary. Within the theory of Chomsky and Halle,<sup>12</sup> (4) and (6) must
be collapsed; however, they are not really collapsible. Rule (4) can be collapsed with the \_CCX\] environment of (6), as in

(7) \[C_1 \ V \ C_0 \ # \ C_1 \ \backslash\ / \ V \ C \ \{C\} \ X\]
   \[1 \quad 2 \quad 3\]
   \[1 \quad \{a\} \quad 3\]

There is no way in which (4) can be combined with the \_C\] environment of (6). Thus, if (4) and (6) are to be collapsed, it must be as

(8) \[C_1 \ V \ C_0 \ # \ C_1 \ \backslash\ / \ V \ C \ \{C \ (C \ X))\}\]
   \[1 \quad 2 \quad 3\]
   \[1 \quad \{a\} \quad 3\]

Stating rules (4) and (6) as (8) seems to miss the point; since the environments of (4) and (6) must be stated separately in (8), it makes no interesting generalization.

Another way to look at this phenomenon is to assume that all short vowels in syllables immediately following prefixes reduce.

(9) \[\backslash\ / \ C_1 \ V \ C_0 \ # \ C_1 \ X \ \#\]

Under this analysis shwa would delete from open syllables immediately following prefixes.

(10) \[\backslash\ / \ C_1 \ X \ # \ C \ V \ Z \ \#\]

Rules (9) and (10) lack the redundancy and complementarity of (4) and (6). The intimate connection between reduction and deletion is captured by (9) and (10), since (9) directly feeds (10).

When a reduplicative prefix precedes a vowel-initial stem, the stem-initial vowel deletes.

(11) -aci:k- 'wring out' paci:ka 'pulls and twists'
    -odg- 'out of a container' potga 'pull out of a container'
    -ote:ga- 'deep into' gwote:ga 'bite deep into'
    -akw- 'across' ?akwa 'puts a long object across'
    -ebli 'back/again' ?ebli 'bring a long object back'

Vowel-initial stems do not occur unprefixed: *aci:ka, *odga, *ote:ga, *akwa, *ebli. Therefore, the question arises whether there is any motivation for positing an underlying
vowel that is always deleted. It has been shown (see (1), (3), and (5)) that the quality of the vowel of the prefix pV-, 'pull', is the same as that of the next following vowel. If there were no underlying initial /a/ in -aci:k-, then when prefixed by pV- it would be *piči:ka. The only way to account for paci:ka is to assume that the stem has an underlying initial /a/ which is deleted by some rule.

Based on the fact that cwe:ka is a well-formed word, it was argued that the underlying form of snecewe:ka is [# sne [# cwe:k + a #] #]. There is no form *aci:ka; therefore, it might be argued that the underlying form of paci:ka is [# pa + aci:k + a #]. Accepting [# pa + aci:k + a #] is to say that pV- is prefixed to strings of the form [# X #] and also to vowel-initial stems. To accept this is to accept an inconsistent morphology. But if the underlying form of paci:ka is [# pa [# aci:k + a #] #], then there will be a consistent morphology. That there is no *aci:ka from [# aci:k + a #] becomes an accident as far as the phonology is concerned and reflects an underlying canonical prohibition against vowel-initial words.

To account for the deletion of the vowel in the derivation of the words in (11), rule (12) is necessary.

\[(12) \quad \tilde{V} \rightarrow \emptyset / [# C_1 V C_1 # X ##] \]

Rule (12) can be collapsed with rules (9) and (10). The premise behind rule (9) is that vowels reduce before they delete. By making the stem-initial consonant of (9) optional, reduction will apply to the first short vowel after the prefix whether it is initial or not.\(^13\)

\[(13) \quad \text{Vowel Reduction} \quad \tilde{V} \rightarrow \emptyset / [# \# X \# C_0 \# Z ##] \]

where Z may contain # boundaries.

Deletion of initial vowels can be combined with deletion from open syllables by making the presence of an initial consonant conditional on there being a following open syllable.

\[(14) \quad \text{Vowel Deletion} \quad \emptyset \rightarrow \emptyset / [# \# X \# (C_1)_\alpha \# (C \ V)_\beta Z ##] \quad \emptyset \cap \beta \]

where Z may contain # boundaries.

Rules (13) and (14) are not limited to application after reduplicative prefixes as the data in (A) illustrates.

(A)  
\[
\begin{align*}
?i\text{?} & \quad 'act on plural objects' \\
[# ?i [# be:Li'i + a #] #] & \quad \hat{\mathbf{?i}}\text{be:Li'i}'a & \quad 'take care of plural objects' \\
[# ?i [# peq + a #] #] & \quad \hat{\mathbf{?i}}\text{peq} & \quad 'puts plural objects on the face' \\
[# ?i [# dang + a #] #] & \quad \hat{\mathbf{?i}}\text{dang} & \quad 'meet (usually prefixed by the reflexive)'
\end{align*}
\]
\[
\begin{align*}
[# ?i [# acw + a #] #] & \quad \hat{\mathbf{?i}}\text{acw} & \quad 'puts plural objects in the hair'
\end{align*}
\]
coq- 'act with the buttocks'

- coq [ # peq + a # ] # coqpqa 'puts the buttocks in someone’s face'
- coq [ # ew + a # ] # coqwa 'puts the buttocks in water'
- coq [ # pes + pes + a # ] # coqpespes a 'wriggles the buttocks around'

These data show that (13) and (14) are very general rules. The vowel of ?i- is always /i/ and the vowel of coq- is always /o/, so in this respect neither of them is like the prefixes which have been discussed thus far. But both ?i- and coq- trigger deletions that are parallel to the deletions triggered by the reduplicative prefixes.¹⁵

3. Two Arguments for the Cycle

In Klamath word-final consonant clusters with /?/ are simplified.

(15) [# loq + ?mc #] loq ?emc 'big old grizzly'
- loq [ # m #] loq ?em 'grizzly’s'
- col? + s # col?es 'calf of the leg'
- del?n + dk # del?antk 'faced'
- giw? + s # giw?es 'pine squirrel'

To account for the data in (15), rule (16) is necessary.

(16) Ø → ? [ X C ? ___ C₁ #]

Rule (16) fails to account for the fact that [# s?ewan? [#ebli #] #] is realized as s?ewan?abal, 'gives plural back'. Glottal stop deletes interconsonantally from three-member consonant clusters.

(17) [# ?i [# ayah? + wapk #] #] ?iyahwapk 'will hide plural objects'
- s?ewanwapk 'will give plural objects'

To account for the epenthesis in s?ewan?abal while blocking epenthesis from applying to the items in (17), rule (16) must be reformulated.

(18) Post-? Epenthesis
Ø → ? [ # X C ? ___ C (C Z) #]

There are no restrictions on the occurrence of intervocalic /?/ or /?/ in the environment C_V.

(19) sle? a 'sees'
- e?elga 'calls (distributive)' from [# e [ # ?elg + a # ] #]
- col? a 'has a cramp in the leg'
- s?oga 'blue crane'
- ak?aka 'stutters'
Consider now the following items.

(20) [ # so [ # ?odi:la + a # ] # ] so:di:la 'puts plural objects underneath'
[ # si [ # ?i:ma:wa + a # ] # ] si:ma:wa 'adds one amount of a substance to another'
[ # si [ # ?i:yo:t + a # ] # ] si:yo:ta 'trade plural objects'

It is clear from the items in (19) that the underlying intervocalic position of /?/ in the items in (20) does not trigger vowel lengthening or deletion of /?/, nor could these changes be triggered by the prefixes, since no such changes occur in ?e?alga.

There are no cases of /?/ in the environment V_C cited by Barker. This suggests that the way to account for the data in (20) is first to have Vowel Reduction (13) and Vowel Deletion (14) apply and then a rule to lengthen the vowel and delete the /?/.

(21) V ? C

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>long</td>
<td>3</td>
</tr>
</tbody>
</table>

(22) [# ?a [ # ?a:la:Y + a # ] # ]

<table>
<thead>
<tr>
<th>?a</th>
<th>?a:la:Y a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel Reduction (13)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>?a</th>
<th>?la:Y a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel Deletion (14)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>?a:</th>
<th>la:Y a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule (21)</td>
<td></td>
</tr>
</tbody>
</table>

Consider now the derivation in (23) which arises if Vowel Reduction, Vowel Deletion, and (21) apply noncyclically. (In postulating noncyclic derivation, I assume that each rule applies simultaneously to all of its environments.)

(23) [ # so [ # so [ # ?o [ # o:di:la + a # ] # ] # ] # ]

<table>
<thead>
<tr>
<th>so</th>
<th>sə</th>
<th>ə</th>
<th>o:di:la</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel Reduction (13)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>so</th>
<th>sə</th>
<th>di:la</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel Deletion (14)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The correct surface form of (23) is sosodi:la, 'shaves (reflexive/distributive)'. In order to block deletion of the /o/ from the reflexive prefix -so-, (21) must apply to lengthen the /o/ so that it will not meet the short-vowel condition of Vowel Reduction. In order for (21) to apply, however, Vowel Reduction and Vowel Deletion first must have applied to delete the /o/ from -odi:la and from -?o- to create an environment for (21).
Thus, to account for (23) we need the rule order:

Vowel Reduction (13)
Vowel Deletion (14)
Rule (21)
Vowel Reduction (13)
Vowel Deletion (14)

Such an ordering, that some rule X must both precede and follow some rule Y within a string, provides a strong argument for cyclical rule application. Given the ordering

Vowel Reduction (13)
Vowel Deletion (14)
Rule (21)

based on (20) and (22), applying these rules cyclically to [#so[#so[# ?o[#odi:1+a#]#]/#]#] yields the correct output.

(24) [# so [# so [# ?o [# odi:1 + a #] #] #] #]

<table>
<thead>
<tr>
<th>1st Cycle</th>
<th>2nd Cycle</th>
<th>3rd Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>?o adi:1 a</td>
<td>?o di:1 a</td>
<td>so:di:la</td>
</tr>
<tr>
<td>(13)</td>
<td>(13)</td>
<td>(13)</td>
</tr>
<tr>
<td>(14)</td>
<td>(14)</td>
<td></td>
</tr>
<tr>
<td>(21)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

not applicable

It is possible for more than one prefix to precede a stem (as (23) illustrates).

(25) wipga
'scapes'
sniwəpga
(causative₁)
snisnwəpgis
(distributive-causative noun)

pe:wa
'bathes'
hespe:wa
(causative₂)
hehəspe:wa
(distributive-causative)

daqca
'scratches someone'
sadəqça
(reflexive)
sasdəqça
(distributive-reflexive)

gəqca
'bends'
pogca
'pulls and bends out of shape'
pogca
(distributive)

If Vowel Reduction and Vowel Deletion applied simultaneously to their possible environments, then [# po [# po [# qoc + a #] #] #] would be realized as *popqca and not popqca.

If these rules apply cyclically, the derivation of popqca is easily accounted for: on the
first cycle, \([# \text{ po } [# q\text{o} c + a ] #]\), Vowel Reduction and Vowel Deletion apply to yield \([# \text{ po } [# q\text{o} c + a ] #]\); on the second cycle, \([# \text{ po } [# \text{ po } q\text{o} c + a ] #]\), Vowel Reduction applies but Vowel Deletion cannot apply because its open syllable environment is not met, and \(p\text{op}q\text{a}c\) is correctly derived.

These arguments for the cycle only support a cycle on each prefix domain and offer no evidence for cyclical rule application to the innermost domain, i.e., \(-\text{odi}:\text{la}\) in (24) and \(-q\text{o}c\) above.

4. Epenthesis

When a reduplicative prefix precedes a sequence of the form \(CV\{w\}\{y\}\), we find, on the surface, a "vocalized glide."

\[
\begin{align*}
\text{njoyl} & : ga & \text{'is numb'} & \text{sonjil} & : ga & \text{(causative)} \\
\text{qayly} & : a & \text{'puts on a belt'} & \text{hasqil} & : y a & \text{(causative)} \\
\text{siw} & : ga & \text{'kills'} & \text{hiso} : ga & \text{(reflexive)} \\
\text{pewqa} & : ya & \text{'embraces'} & \text{sepo} : qy & : a & \text{(reflexive)} \\
\text{siw} & : ga & \text{'kills'} & \text{siso} : qa & \text{(distributive)} \\
\text{gayk} & : a & \text{'is silly'} & \text{gagi} : ka & \text{(distributive)}
\end{align*}
\]

There are several ways in which these data might be accounted for. One might argue that when a vowel-{\(w\)} sequence is preceded by a reduplicative prefix, the vowel assimilates to the glide and becomes long.

\[
V \rightarrow \begin{cases} +\text{long} \\ +\text{high} \\ \text{eback} \end{cases} / \begin{array}{c} \# \text{ C}_1 \text{ V} \text{ C}_0 \# \text{ C}_1 \\ +\text{son} \\ +\text{high} \\ \text{eback} \end{array} \frac{\text{C} \times \#\#}{}
\]

The glide would then delete by a general rule which takes \(o(:)wC\) and \(i(:)yC\) to \(o:C\) and \(i:C\), respectively. Support for this analysis is that the latter rule is independently motivated as the derivation in (28) illustrates.

\[
\begin{align*}
\text{Vowel Reduction (13)} \\
\text{Vowel Deletion (14)} \\
\text{Glide Lengthening/Deletion}
\end{align*}
\]

Consider now these data.

\[
\begin{align*}
\text{v} & : \text{conwa} & \text{'vomits'} & \text{v} & : \text{cono} : ye\text{g}: a & \text{'starts to vomit'} \\
\text{v} & : \text{conw} + ye\text{g} + a \\
\text{v} & : \text{cono} : \text{nap} \text{g} \text{a} & \text{'feels like vomiting'} \\
\text{v} & : \text{conw} + \text{nap} \text{g} + a \\
\text{v} & : \text{somalo} : ye\text{g} : a & \text{'starts to write'} \\
\text{v} & : \text{somalw} + ye\text{g} + a
\end{align*}
\]
It is clear that rule (27) offers no explanation for why the glides vocalize in (29), since there is no reduplicative prefix and no vowel-

\[ \{w \} \]

sequence. Therefore, if (27) is to be maintained, a second rule of vocalization such as (30) will be needed.

\[
(30) \quad [\begin{array}{c}
-syl \\
+son \\
+high
\end{array}] \quad \rightarrow \quad [\begin{array}{c}
+syl \\
+long
\end{array}] / \quad [\# X C \quad C \quad Y \#]
\]

If we accept (27) and (30), we have no uniform way of accounting for the vocalization of glides. Rules (27) and (30) are totally unrelated and acceptance of them implies that it is purely accidental that we find on the surface /o:/ and /i:/ derived from glides in (26) and (29). This is a very weak solution.

A second way in which the data in (26) might be accounted for would be to delete the preglide vowel from sequences of the form \( CV \{w \} C \) when preceded by reduplicative prefixes. By such a solution only rule (30) would be needed to account for the vocalization of glides.\(^{18}\) There is, however, a serious problem with such an analysis; not all interconsonantal glides vocalize.

\[
(31) \quad [\# \text{bonw} + s \#] \quad \text{bonwəs} \quad \text{'drink'}
\]

\[
[\# \text{delwg} + s \#] \quad \text{delwəks} \quad \text{'attack'}
\]

\[
[\# \text{sgoyw} \{\# \text{alcwi} \#\}] \quad \text{sgoywalcwi} \quad \text{'send someone right up to'}
\]

\[
[\# \text{s?aywg} + s \#] \quad \text{s?aywaugs} \quad \text{'knowing'}
\]

To account for the data in (31), it is necessary to postulate the rule:

\[
(32) \quad \emptyset \quad \rightarrow \quad \emptyset / \quad [\# X V C \quad w \quad \_\_\_ \quad C \quad (C \ Z) \#]
\]

Rule (32) must be ordered before rule (30) in order to block (30) from applying to the words in (31). But if (32) applies first, we would expect the following items to be good.

\[
(33) \quad [\# \text{calw} + ys \#] \quad ^{\text{phasis}}\text{calwsy}s
\]

\[
[\# \text{iww} + ys \#] \quad ^{\text{phasis}}\text{iwwsy}s
\]

The surface forms in (33) derived by rule (32) are incorrect. They should be thus.\(^{20}\)

\[
(34) \quad [\# \text{calw} + ys \#] \quad ^{\text{phasis}}\text{calwis} \quad \text{'rotten fish'}
\]

\[
[\# \text{iww} + ys \#] \quad ^{\text{phasis}}\text{iwwis} \quad \text{'back of the knee'}
\]

The surface forms in (34) can only be derived if rule (30) precedes rule (32). Thus acceptance of a solution involving rule (30) leads to an ordering paradox.

Rule (30) vocalizes glides as long vowels. While glide/vowel alternations are found
in many languages, it would be unusual for there to be a rule vocalizing interconsonantal glides as long vowels. Thus a solution based on (30) does not seem natural.

A third way in which the data in (26) might be accounted for is to allow Vowel Reduction to apply and have a rule to 'vocalize' schwa-glide sequences. The first argument in favor of the vocalization of \( w \) sequences is that it requires no ad hoc mechanism to account for vocalization after prefixes; all vocalized elements are derived from such sequences and in the case of vocalization after prefixes the schwa is derived by an independently motivated rule. Accepting this proposal leads to derivations such as these:

\[
(35) \quad \text{\# si \# siwg + a \# #} \quad \text{'kills (distributive)'}
\]

\[
\text{si səwg a Vowel Reduction (13)}
\]

\[
\text{si so:g a Vocalization}
\]

\[
\text{\# ga \# gayk + a \# #} \quad \text{'is silly (distributive)'}
\]

\[
\text{ga gəyk a Vowel Reduction (13)}
\]

\[
\text{ga gi:k a Vocalization}
\]

By claiming that schwa-glide sequences vocalize, we also have a means of accounting for the data in (34) and (36).

\[
(34') \quad \text{\# calw + ys \#} \quad \text{'rotten fish'}
\]

\[
\text{calw θys Rule (32)}
\]

\[
\text{calw i s Vocalization}
\]

\[
\text{\# ?iww + ys \#} \quad \text{'back of the knee'}
\]

\[
\text{?iww θ ys Rule (32)}
\]

\[
\text{?iww i s Vocalization}
\]

\[
(36) \quad \text{\# ge \# elwy + bg + a \# #} \quad \text{gelwipga 'goes by fire'}
\]

\[
\text{\# slo \# slo:lw + ys \# #} \quad \text{sloslo:lwis 'flute player'}
\]

\[
\text{\# spel + w + ys \#} \quad \text{spelwis 'index finger'}
\]

A third argument in favor of this solution is that there are underlying θy sequences that are realized as /i:/.

\[
(37) \quad \text{\# ndo \# ogθ + ys \# #} \quad \text{ndogi:s 'hawk'}
\]

\[
\text{\# go \# gwo \# ogθ + ys \# #} \quad \text{gogo:gis 'habitual biter'}
\]

\[
\text{\# scilikθ + ys \#} \quad \text{scilikis 'frown'}
\]

Therefore, a rule to take schwa-glide sequences to vowels with the quality of the glide is independently motivated.

In Klamath there is a fairly complex system of epenthesis rules which simplify consonant clusters and interact with vocalization. Consonant clusters of the form \( C\text{[+son][+cons]} C_2 \) are broken up by an epenthetic schwa before the sonorant.
Three member clusters with a medial sonorant are not broken up. Thus we find ?esnka, 'weeps hard', and not *?esnka.

Given a cluster with two internal sonorants, the epenthetic vowel is inserted before the leftmost sonorant.

(39) [# hon [# awl [# elg + a #] #] #] 'flies up'

awl elg a
awl elg a
awl elg a

hon awel elg a
hon awel elg a

1st Cycle

2nd Cycle

Vowel Reduction (13)
Vowel Deletion (14)
Epenthesis

To account for these data rule (41) is necessary.

(41) Sonorant Cluster Rule

\[ \emptyset \rightarrow \varepsilon / [\# X C \quad \begin{array}{c} + \text{son} \\ + \text{cons} \end{array} C_2 Y # ] \]

As the data in (39) and (40) show, rule (41) bleeds the rules which give vocalized glides.

Word-final \(C\{1\}_{m}\) clusters are not tolerated as these data illustrate.

(42) [# b + e: + y + m #] be:yəm 'daughter'
[# b + e: + ys + m #] be:ysəm 'daughter's'
[# sla:l + m #] sla:ləm 'fir tree'
[# tgalm #] tgaləm 'west'
Word-final clusters ending in /n/ are not subject to epenthesis.

(43) 

Final /l/ and /m/

That this rule is restricted to final clusters is evident by comparing koməl, 'pelican', with komlə:k, 'little pelican', and tgaləm, 'west', with tgalmas, 'west wind'.

To account for the data in (31), rule (32) was postulated. Rule (32) predicts that [snog + wk #], 'to cool by blowing on', is realized as snogwə:k; however, [snog + wk #] is realized as snogə:k. In all of the examples in (31) the /w/ is preceded by a sonorant. Therefore if (32) is restricted to applying after [+son] w clusters, it will be blocked from applying in the derivation of snogə:k.

(45) Idiosyncratic /w/

Consider now these data.

(46) 

If the initial vowel of -awl is deleted before the application of the epenthesis rules, then we would find [mpaq [awl #] #] → [mpaq # wl #]. Since /w/ is not preceded by a sonorant, rule (45) will not apply. These forms can be accounted for by rule (44), however, irrespective of any ordering with Vowel Deletion.

Rule (45) only affects clusters with /w/ as these data show.

(47) 

Consider now the paradigm:

(48) 

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To account for the data in (48), rule (49) is necessary.

(49)  \[ \emptyset \rightarrow \theta / [ \# X V [+\text{son}] Y [+\text{cons} \backslash ] (C Z) \# ] \]

With the exception of Vowel Reduction (13) and Idiosyncratic /w/ (45), all rules discussed thus far bleed the vocalization of glides. In order to account for the vocalization of the glides in (29), it is necessary to postulate another epenthesis rule. Based on (29), rule (50) might be postulated as the appropriate epenthesis rule.

(50)  \[ \emptyset \rightarrow \theta / [ X V C \{w\} C_1 Z ] \]

Rule (50) is not, however, descriptively adequate as these data show.

(51)  \[ \# \text{slankws} +\text{ksi} \# \quad \text{slankoski} \quad \text{Bridge Place}' \]
      \[ \# \text{sasalgy} \# \text{odg + a} \# \# \quad \text{sasalgitga} \quad \text{been quarreling}' \]

To account for (51), (50) must be reformulated.

(52)  \[ \emptyset \rightarrow \theta / [ X C \{w\} C Z ] \]

Rule (52) fails to account for these data.

(53)  \[ \# \text{dewy} \# \quad \text{dewi:} \quad \text{'shoot a bow and arrow'} \]
      \[ \# \text{lagy} \# \quad \text{lagi:} \quad \text{'misses someone'} \]
      \[ \# \text{mbely} \# \quad \text{mbeli:} \quad \text{'is cross-eyed'} \]
      \[ \# \text{nidy} \# \quad \text{nido:} \quad \text{'guesses'} \]
      \[ \# \text{spony} \# \quad \text{sponi:} \quad \text{'tosses'} \]

Rule (52) fails to account for these data because the consonant to the right of the glide is not optional. Therefore (52) must be reformulated.

(54)  \[ \emptyset \rightarrow \theta / [ \# X C \{w\} (C Z) \# ] \]

Three arguments have been given for deriving vowels from schwa-glide sequences: the first was that such a solution was consistent with Vowel Reduction (13); the second that it explained vocalization after the application of Idiosyncratic /w/ (45); and third that there was an independently motivated schwa-glide to vowel rule. Acceptance of a schwa-glide source requires acceptance of (54). It has been shown that in Klamath there are epenthesis rules that simplify consonant clusters; thus, (54) is consistent with a general phenomenon. Additional support for (54) is gained by comparing it with Idiosyncratic /w/ (45) and Idiosyncratic /y/ (49).
There is a strong similarity between these rules; (45) and (49) seem much like special cases of (54); in their most abstract expanded form they insert a schwa in the environment XCC ___ CCZ. There is, in fact, in Klamath a rule that breaks up many such clusters as is illustrated by these data.

(55) [# ?i [# adg + bli #] #] ?idgoblili 'takes plural objects out of a container again'
    [# s ?eqg [# odg + a #] #] s ?eqgatga 'been saying goodbye to someone'
    [# lo [# op + bli #] #] locpa bli 'takes a ring back off'

Thus not only is (54) consistent with a general tendency, but, in view of (55), it is the predicted case.

5. Cycle and Strict Cycle

When wayasga, 'falls on the genitals', is nominalized and preceded by the causative prefix, [# has [# wayasg + ys #] #], it is realized as haso:yasgis, 'loin cloth'. In order to account for the vocalization of /w/ in haso:yasgis, Vowel Deletion (14) must precede Pre-Glide Epenthesis (54), since it is only by the application of (14) that an environment for (54) is created.

(56) [# has [# wayasg + ys #] #] 'loin cloth'
    has w ɔ_ yasg ys Vowel Reduction (13)
    has ɔ w ɔ_yasg ys Vowel Deletion (14)
    has ɔw ɔ_yasg ɔys Pre-Glide Epenthesis (54)
    has o: ɔ_yasg is Vocalization

If Vowel Deletion precedes Pre-Glide Epenthesis, a problem arises in accounting for [# de [# dewy #] #] which is realized as dedwi, 'shoot a bow and arrow (distributive)'. By Vowel Reduction (13), [# de [# dewy #] #] goes to [# de # dɔwy ##]. Rule (14) cannot apply to [# de # dɔwy ##], since its open syllable condition is not met. Thus the ordering of (14) and (54) which is necessary to account for (56) yields the wrong results in (57).

(57) [# de [# dewy #] #] 'shoot a bow and arrow (distributive)'
    de dɔwy Vowel Reduction (13)
    not applicable Vowel Deletion (14)
    * de dɔwy Pre-Glide Epenthesis (54)
The only way to account for dedwi is to have Pre-Glide Epenthesis apply before Vowel Deletion.

(58)  
\[
\begin{array}{l}
\text{[# de [# dewy #] #]} \\
\text{dew@y} & \text{Pre-Glide Epenthesis (54)} \\
\text{de d@way} & \text{Vowel Reduction (13)} \\
\text{de dw@y} & \text{Vowel Deletion (14)} \\
\text{de dwi} & \text{Vocalization}
\end{array}
\]

The ordering paradox posed by (56) and (58) can be resolved if Vowel Deletion is ordered before Pre-Glide Epenthesis and the rules apply cyclically from the innermost bracketing.

(59)  
\[
\begin{array}{l}
\text{[# has [# wayasg + ys #] #]} \\
\text{wayasg @ys} & \text{Pre-Glide Epenthesis (54)} \\
\text{has w@ysg @ys} & \text{Vowel Reduction (13)} \\
\text{has w yasg @ys} & \text{Vowel Deletion (14)} \\
\text{has o: yasg is} & \text{Vocalization}
\end{array}
\]

In Kean\textsuperscript{5} it was argued that cyclic phonological rules must conform to the principle of strict cyclicity.

(60)  
\[
\begin{array}{l}
\text{[# de [# dewy #] #]} \\
\text{dew@y} & \text{Pre-Glide Epenthesis (54)} \\
\text{de d@way} & \text{Vowel Reduction (13)} \\
\text{de d w@y} & \text{Vowel Deletion (14)} \\
\text{de d wi} & \text{Vocalization}
\end{array}
\]

The principle of strict cyclicity provides an explanation of why[# hq# awI[# elg[# obg + a #] #] #] is realized as niqw@llqpga, 'keeps a hand raised'.
The question arises about why the Sonorant Cluster rule fails to apply on the fourth cycle of (62), since its domain is met by $-llgbg-$. By the principle of strict cyclicity (41) cannot apply to this string on the fourth cycle because it is wholly within the domain of the previous cycle. Therefore, it is only by accepting the principle of strict cyclicity as a constraint on the application of cyclic phonological rules that forms such as those in (62) can be accounted for.

6. Vocalization

Vowels derived by Vocalization vary in length. Schwa-glise sequences vocalize as long vowels in the environment VC____.

$\quad [\# \ \text{dewy } \#] \rightarrow [\# \ \text{dewy } \#] \rightarrow \text{dewi:} \quad \text{'shoot a bow and arrow'}$
$\quad [\# \ \text{mbely } \#] \rightarrow [\# \ \text{mbely } \#] \rightarrow \text{mbeli:} \quad \text{'is cross-eyed'}$
$\quad [\# \ \text{tawy } \#] \rightarrow [\# \ \text{tawy } \#] \rightarrow \text{tawi:s} \quad \text{'curse'}$
$\quad [\# \ \text{nidy } \#] \rightarrow [\# \ \text{nidy } \#] \rightarrow \text{nido:} \quad \text{'guesses'}$
$\quad [\# \ \text{delwy } \#] \rightarrow [\# \ \text{delwy } \#] \rightarrow \text{delo:ks} \quad \text{'to attack'}$

In the environment V:C____, schwa-glise sequences vocalize as short vowels.21

$\quad [\# \ \text{loto:wy } \#] \rightarrow [\# \ \text{loto:wy } \#] \rightarrow \text{loto:wi} \quad \text{'gives an arm-load of objects'}$
$\quad [\# \ \text{bsey } \#] \rightarrow [\# \ \text{bsey } \#] \rightarrow \text{bseyip} \quad \text{'uncle'}$
$\quad [\# \ \text{qdoc:v } \#] \rightarrow [\# \ \text{qdoc:v } \#] \rightarrow \text{qdocok} \quad \text{'because of rain'}$
$\quad [\# \ \text{meqy } \#] \rightarrow [\# \ \text{meqy } \#] \rightarrow \text{meqis} \quad \text{'cry-baby'}$

Based on the data in (63) and (64), rule (65) is needed.

$\quad V \quad C \quad \emptyset \quad [+\text{son}] \\
\quad [\text{elong}] \quad +\text{high} \\
\quad 1 \quad 2 \quad 3 \quad 4 \\
\quad 1 \quad \emptyset \quad [+\text{son}] \\
\quad [\text{elong}] \quad 4$
In the environment $[# X # C_1 ___ C_1 V Z #]$, a schwa-glide sequence is realized as a long vowel.

(66) $[# sne [# ntw + lg + a #] #]$

'sdrops'

sne $ntw lg a$

snento:lg

$[# do [# okcw + wabg #] #]$

'will fall into water headfirst'

do $kcew wabg$

dokco:wapk

$[# qba [# qbaty + wabg #] #]$

'will wrap their legs around something'

qba $qbaty wabg$

qba$qbaty:wapk$

$[# hos [# qyg + a #] #]$

'introduces someone'

hos $qyg a$

hos$qyg:ga$

$[# s?o [# s?oys? + a #] #]$

'are thin (distributive)'

s?o $s?oys? a$

s?o$s?oys?:a$

Rule (67) accounts for the data in (66).

(67) $X # C_1 \quad \Theta \quad +son \quad +high \quad \boxed{C_1 V Z}$

$1 \quad 2 \quad 3 \quad 4$

$1 \quad \emptyset \quad +syl \quad +long \quad 4$

In all other environments, schwa-glide sequences are realized as short vowels.

(68) $[# de [# dewy #] #]$

'shoot a bow and arrow'

de $dw\text{y}$

dedwi

$[# si [# midw #] #]$

'make an estimate of each other'

si $nd\text{w}$

sindo
The reason that (67) does not apply to the words in (68) is that there is no -C₁V following the schwa-glide sequence. Rule (67) does not apply in (69) because a #-boundary falls within the -C₁V condition and there is no provision in (67) for the intrusion of such a boundary.

The data in (68) and (69) must be accounted for by an 'elsewhere' rule. If (65) and (67) are ordered before this rule, it can be stated as follows.

\[
(70) \quad X \quad C \quad \alpha \quad \begin{array}{c}
+\text{son} \\
+\text{high}
\end{array} 
\quad Z \\
1 \quad 2 \quad 3 \quad 4 \\
1 \quad \emptyset \quad \begin{array}{c}
+\text{syl} \\
-\text{long}
\end{array} 
\quad 4
\]

The rules of vocalization are, necessarily, post-cyclic. If they applied cyclically \[# \text{de} \ [# \text{dewy} \] \#] would be realized as \text{dedwi}; and \[# \text{slan} \ [# \text{akw} + \text{s} \] \#] would be realized as \text{slankos}.

\[
(71) \quad \begin{array}{c}
+\text{son} \\
+\text{high}
\end{array} 
\quad \text{Z}_{\text{long}} \\
\quad \text{1st Cycle}
\]

\text{dew} \text{y} \\
\text{dewi}; \\
\text{dedwi}; \\
\text{dewi:} \\
\text{dewi:}

\text{1st Cycle}

\begin{array}{c}
\text{Pre-Glide Epenthesis (54)} \\
\text{Vocalization (65)}
\end{array}

\text{2nd Cycle}

\begin{array}{c}
\text{Vowel Reduction (13)} \\
\text{Vowel Deletion (14)}
\end{array}

\text{QPR No. 108 305}
7. Kisseberth's Rules for Klamath

Let us turn now to the analysis of these data presented by Kisseberth. Kisseberth proposes that the underlying forms of the reduplicative prefixes are as given in (K-1).

(K-1) snV* causative<sub>1</sub>
    hV*s causative<sub>2</sub>
    sV* reflexive
    pV* 'pull off'
    R distributive

Under his analysis a rule of reduplication applies to strings such as that in (K-2a) to yield strings such as that in (K-2b).

(K-2) (a) [ R + pe:wa ]
     (b) [ pV* + pe:wa ]

The pro-vowel, V*, triggers a rule of Vowel Copy which specifies V* as a short copy of the vowel of the adjacent syllable to the right.

(K-3) Vowel Copy
The ultimate phonetic realization of this pro-vowel will be specified by a rule which will copy the quality of the next following vowel onto the pro-vowel, also specifying the latter as being a short vowel.

To account for the items in (3) where a short vowel has been deleted from an open syllable preceded by a reduplicative prefix, and to provide an appropriate environment for Vocalization to apply to the items in (26), Kisseberth proposes a rather radical rule of Vowel Deletion.

(K-4) Vowel Deletion
Short Vowels simply drop after being copied onto a preceding pro-vowel [V*].

QPR No. 108 306
There are some serious problems with Kisseberth's rule of Vowel Deletion. Consider the following data.

(72) ?i- 'act on plural objects'
[ # ?i [ # be:Li' + a # ] # ] ?ibe:li'ta 'take care of plural objects'
[ # ?i [ # peq + a # ] # ] ?ipqa 'puts plural objects on the face'
[ # ?i [ # dang + a # ] # ] ?id nga 'meet (usually prefixed by the reflexive)'
[ # ?i [ # achw + a # ] # ] ?icwa 'puts plural objects in the hair'

<coq - 'act with the buttocks
[ # <coq [ # peq + a # ] # ] <coqpeqa 'puts the buttocks in someone's face'
[ # <coq [ # ew + a # ] # ] <coqwa 'puts the buttocks in water'
[ # <coq [ # pe:s + pes? + a # ] # ] <coqpe:pes?a 'wriggles the buttocks around'

To account for these data Vowel Reduction (13) and Vowel Deletion (14) are needed. Therefore, even if we accept (K-4), we still need (13) and (14). Rule (K-4) is redundant in a grammar with (13) and (14).

There is a second serious problem with (K-4). As is illustrated in (5), when a reduplicative prefix precedes a closed syllable, the vowel of that syllable does not delete but rather undergoes reduction. Given Kisseberth's (K-4) rule of Vowel Deletion, it is necessary for him to propose a global insertion rule to account for these forms. Since (K-4) creates the environment for Vocalization in Kisseberth's analysis, the insertion rule must be ordered after Vocalization. As with (K-4), Kisseberth offers no formal statement of the following insertion rule. 27

(K-5) /a/-insertion
If, after Vocalization has applied, there exists a sequence of at least three consonants immediately preceded by a reduplicative prefix, and if prior to some application of Vowel Deletion [K-4] there existed a sequence of the form -CVCC- or CCVC# in a syllable immediately preceded by a reduplicative prefix, then an /a/ is inserted in the space which was occupied by the vowel prior to the application of Vowel Deletion.

If, instead of accepting Kisseberth's rule of Vowel Deletion, rules (13) and (14) are accepted, there is no need for a global insertion rule like (K-5). As the data in (72) show, even if we accept (K-5), rule (13) is still necessary. Therefore, there seems to be no support for (K-5).

Kisseberth claims that glides, and not schwa-glided sequences, vocalize in the
environment C C. He does not consider the data in (31), which is accounted for by Idiosyncratic /w/ in (45), or the data in (48) which is accounted for by Idiosyncratic /y/ in (49). Therefore, he predicts that [# bonw + s #] is realized as *bono:s and [# ?i
[# iwyg #] #] as *?iwi:q.

According to Kisseberth glides are vocalized as short vowels in the environments: V:C 0, C 2 C 0#, and C 2 C 2; and they are realized as long vowels in the environments V:C 0 and VC 1 CV. The V:C 0 environment suggests that [# ca:yca:ys #] might go to *[# ca:ica:1s #] in the derivation of ca:yca:ys, 'sleet'. The C 2 C 2 environment predicts that [# sne [# ntwi + lg + a #] #] will be realized as *snentolga and not as snenfo:iga, 'drops'.

Kisseberth argues:

(73) Since the conditions which determine the length of the vocalized glide are not relevant to the actual vocalization process itself, it is natural to try to state the rule of vocalization separately from the rule accounting for the length alternation. 29

Under this analysis vocalization yields long vowels and then a shortening rule applies. The shortening rule must be a global rule so that it can be blocked from applying to underlying long vowels.

\[\begin{align*}
(K-6) & V \\
& [+long] \rightarrow [-long] / \\
& \begin{cases} 
V \\
C 0 \\
C 0 \\
C 2 \\
C 2 \\
\end{cases}
\end{align*}\]

where the input to the rule has been derived by Vocalization. Even if global rules are accepted in principle, (K-6) cannot be accepted because it is not descriptively adequate, i.e., [# sne [# ntwi + lg + a #] #] goes to *snentolga by (K-6).

While it would be nice to be able to account for vocalization with only one rule, it is not possible. By having to limit (K-6) to vowels derived by Vocalization, Kisseberth has, in effect, proposed two rules of vocalization. The 'generalization' captured by vocalizing all interconsonantal glides as long vowels is spurious because of this.

It has been my aim to show that the data discussed by Kisseberth do not warrant the postulation of global rules. It has been shown that his rule of Vowel Deletion (K-4) is both too general, i.e., it needlessly deletes vowels, and too specific, i.e., it does not account for deletion after nonreduplicative prefixes. I have argued that the proposed rule of /a/-insertion (K-5) is phonetically and phonologically uninciteful, that it is too specific, i.e., it does not account for reduction after nonreduplicative prefixes, and it introduces a globality which is only warranted to the extent that Vowel Deletion (K-4) is
supported. Kisseberth's global rule of vowel shortening fails to account for the data and fails to meet its own motivation, which is to have only one rule of vocalization.

I wish to thank Morris Halle for convincing me that my analysis of some of these data in Quarterly Progress Report No. 106 (pp. 151-159) just could not be right and for many helpful suggestions.

References and Footnotes

6. The sources for the data discussed here are Barker, the same sources that Kisseberth relied on. I have restricted myself to Barker's material in order to show that the corpus Kisseberth used does not support his claims.
9. The forms cited in (1) are in the indicative which generally has a \( \emptyset \) realization after morpheme-final vowels \( w \), \( y \), and \( n \), and which is realized as -a elsewhere. The causative prefixes differ in degree, causative, implying more forceful causation, usually by direct or applied force. The reflexive prefix is interpreted as reflexive or reciprocal, depending on the semantics of the verb.
10. For reasons about which I can only speculate, Kisseberth treats the reduced vowel of the items in (5) as /a/. It is true that Barker uses /a/ to represent this vowel in his transcriptions; however, Barker points out that often /a/ is realized as schwa. Barker worked within a taxonomic framework and it is a consequence of his theory that he represents the reduced vowel of the items in (5) as /a/.

Within the framework of generative grammar, it is, at best, misleading to characterize the reduced vowels in (5) as /a/.

13. The need for the condition on \( Z \) in (13) and (14) is based on examples like (23),
14. ?i- appears as ?e- before en, 'action away', as in ?ena, 'take plural objects away', and ebg, 'action toward', as in ?epga, 'bring plural objects'. Elsewhere it is always ?i-.

15. The intensive morpheme does not trigger reduction and deletion as do the other reduplicatives.

<table>
<thead>
<tr>
<th>Verb</th>
<th>Meaning</th>
<th>Intensive Form</th>
<th>Strong Intensive Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>teka</td>
<td>'burns'</td>
<td>tekteka</td>
<td>be:mmbema</td>
</tr>
<tr>
<td>dopa</td>
<td>'boils'</td>
<td>dopdopa</td>
<td></td>
</tr>
<tr>
<td>bema</td>
<td>'is confused'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It may be the case that the intensive is marked as being minus both (13) and (14). Alternatively, the intensive forms may not meet the structural descriptions of (13) and (14); i.e., the structure of tekteka may be [# tek+tek+a #] and not [# tek [# tek+a #] #]. Just how the intensive is to be handled will have to be decided on the basis of further study.

16. Kisseberth has argued that rule (21) should be combined with the rule which deletes 1/7/ from the environment C C. I think such collapsing is a mistake and that the deletion of 1/7/ can be accounted for by a later noncyclic rule which deglottalizes segments in pre-consonantal position. The rule of deglottalization is given cursory treatment in Kisseberth.


18. The formulation of a deletion rule such as would be required by a solution using only rule (30) is suggested in Kean.


20. Not all vowels derived by vocalization are long, as the data in (34) illustrate. In section 6 the vowel length of vocalized elements is discussed. For the present discussion it is irrelevant whether vocalization yields long or short vowels.

21. I know of only one counterexample to this rule: [# ke: [# aywwi #] #] is realized as ke:yo:wi, 'throws a handful'. Therefore, ke:yo:wi probably is the result of a speaker's error or a transcription mistake.

22. I know of only one counterexample to this rule: [# s?i [# s?in + ys #] #] s?is?i:s, 'one who habitually has coitus'. Presumably, s?is?i:s like ke:yo:wi is a mistake of some sort.

23. That the boundaries are transparent in epenthesis rules is not surprising, since epenthesis rules apply to the concatenation of morphemes. Since rules such as the vocalization rules apply to sequences of segments and not concatenations of morphemes, they are therefore a very different type of rule.


25. Kisseberth assumes that glides, and not schwa-glide sequences, are vocalized in the environment C C.


27. As I have pointed out (see fn. 10), Kisseberth treats the reduced vowel of the words in (5) as /a/. (K-5) is my summary of Kisseberth's discussion.
