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

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.

<div align="right">M. Halle</div>

A. A REVISED DIRECTIONAL THEORY OF RULE APPLICATION IN PHONOLOGY

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

$$(1) \quad \ddot{o} \longrightarrow e \; / \; \begin{bmatrix} V \\ -round \end{bmatrix} (C_0 \ddot{o})^* \; C_0 \; \underline{\quad\quad}$$

In order for such a rule to describe a propagation, the material within ( )* must duplicate the <u>focus</u> or input (here ö), plus elements from the nonrepeating environment (here C_0), 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

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

$$(2) \quad \text{ö} \longrightarrow \text{e} \quad / \quad \begin{bmatrix} V \\ -\text{round} \end{bmatrix} X \underline{\quad\quad}$$

But X must be constrained to include no other round front vowel. The rule never operates over ü̲, ű̲, or ő̲ (where ű̲, ő̲ represent long versions of ü̲, ö̲), although it does operate over ö̲ if this ö̲ is itself converted to e̲. The rule must derive (3b) from (3a):

(3) a. szövet + ötök + höz

  b. szövetetekhez   '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. kezelő̋höz   'toward (the) operator'

  b. hegyükhöz   'toward their hill'

(5) a. *kezelő̋hez

  b. *hegyükhez

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

$$(6) \quad \text{X contains no segment of the form} \quad \begin{bmatrix} V \\ +\text{round} \\ \left\{ \begin{matrix} [+\text{high}] \\ [+\text{long}] \end{matrix} \right\} \end{bmatrix}$$

But both formulations (1) and (2) miss the obvious generalization that ö̲ 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:

(7) $\ddot{o} \longrightarrow e$ / $\begin{bmatrix} V \\ -\text{round} \end{bmatrix} C_o$ _____ (L-R iterative)

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) $[\ ] \longrightarrow [+F]$ / $[-F] C_o$ _____

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:
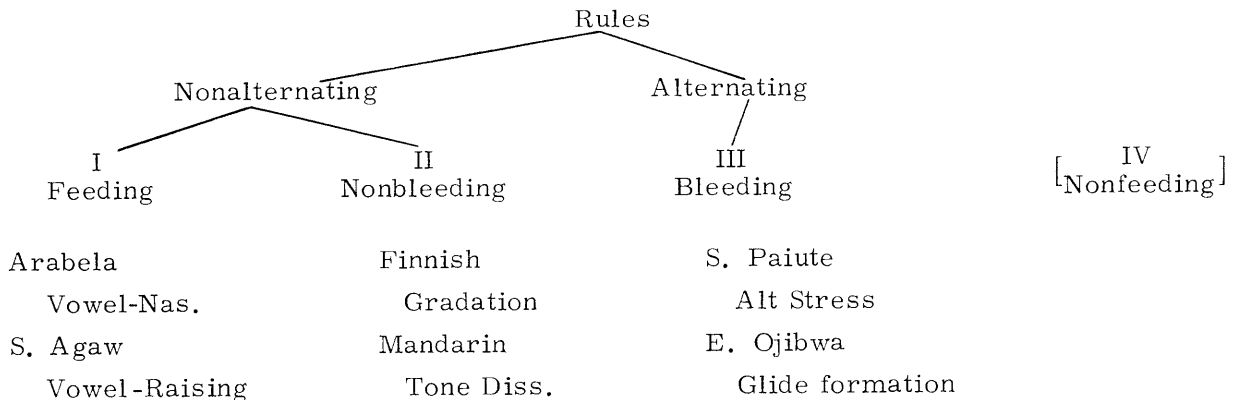
(9) a. $[\ ] \longrightarrow [+F]$ / $[-F] C_o ([-F] C_o [-F] C_o)^* $ _____

b. $[\ ] \longrightarrow [+F]$ / $[-F] C_o$ _____   (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. $[-F] C_o [-F] C_o [-F] C_o [-F] C_o [-F] C_o [-F] C_o$

b. $[-F] C_o [+F] C_o [-F] C_o [+F] C_o [-F] C_o [+F] C_o$

c. $[-F] C_o [+F] C_o [+F] C_o [+F] C_o [+F] C_o [+F] C_o$

Irwin Howard[6] 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.

	Nonalternating		Alternating	
	I Feeding	II Nonbleeding	III Bleeding	[IV Nonfeeding]
	Arabela Vowel-Nas.	Finnish Gradation	S. Paiute Alt Stress	
	S. Agaw Vowel-Raising	Mandarin Tone Diss.	E. Ojibwa Glide formation	

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

$$\begin{bmatrix} +\text{syll} \\ -\text{low} \end{bmatrix} \longrightarrow [+\text{high}] \ / \ \underline{\hspace{1cm}} \ C_o \begin{bmatrix} +\text{syll} \\ +\text{high} \end{bmatrix} \ (\text{R-L iterative})$$

      b. Arabela Vowel Nasalization

$$[-\text{cons}] \longrightarrow [+\text{nas}] \ / \ [+\text{nas}] \ \underline{\hspace{1cm}} \qquad (\text{L-R iterative})$$

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

$$(12) \quad C_i C_i \longrightarrow C_i \ / \ \underline{\hspace{1cm}} \begin{bmatrix} +\text{syll} \\ \text{str} \neq 1 \end{bmatrix} \ (\text{j}) \ [-\text{syll}] \left\{ \begin{bmatrix} -\text{syll} \\ \# \end{bmatrix} \right\}$$

(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. /'nuwa$^{?}$/

      b. ['nũw̃ã$^{?}$]

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

(14) $*[\text{'n\~uwa?}]$

(14) is opaque[7] 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 | | |
| b.   rokko + tta + va | rokottava | rokottava |
| c.   rokko + tt + utta + va | rokotuttava | *rokkotuttava |
| d.   rokko + tt + utta + tte | rokotutatte | *rokottutatte |

R-L application in (16b) degeminates 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 3 ⟶ 2 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[8] 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) $[+syll] \longrightarrow [+stress]$ / $\breve{V}$ 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. $\breve{V}$ $\breve{V}$ $\breve{V}$ $\breve{V}$ $\breve{V}$ $\breve{V}$ $\breve{V}$ $\breve{V}$ $\breve{V}$

b. $\breve{V}$ $\acute{V}$ $\breve{V}$ $\acute{V}$ $\breve{V}$ $\acute{V}$ $\breve{V}$ $\acute{V}$ $\breve{V}$

Similarly, rules of glide formation operate to produce alternating patterns; for example, Eastern Ojibwa Glide Formation[9] given as

(22) $\begin{bmatrix} +syll \\ -low \end{bmatrix} \longrightarrow \begin{bmatrix} -syll \\ +high \end{bmatrix}$ / _____ $[+syll]$

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

(23) a. /eninioak/

b. [eniniwak]   'men'

by applying right-to-left. The reverse direction of application (or simultaneous appli-
cation) 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 appar-
ent 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 con-
sidered 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 power-
ful device; it also avoids the extensions of conjunctive and disjunctive ordering that are
needed to make simultaneous rules work.

References

1. N. Chomsky and M. Halle, The Sound Pattern of English (Harper and Row Publishers, Inc., New York, 1968).

2. S. R. Anderson, "West Scandinavian Vowel Systems and the Ordering of Phonological Rules," Ph.D. Thesis, Department of Modern Languages and Linguistics, M.I.T., September 1969 (unpublished).

3. This rule is discussed in greater detail in J. T. Jensen, "Hungarian Phonology and Constraints on Phonological Theory," Ph.D. Dissertation, McGill University, 1972 (unpublished).

4. C. W. Kisseberth, "An Argument against the Principle of Simultaneous Application of Phonological Rules," Ling. Inquiry, Vol. 3, No. 3, pp. 393-396, Summer 1972.

5. J. R. Vergnaud, "On the Formalization of Infinite Sets of Phonological Rules," Quarterly Progress Report No. 104, Research Laboratory of Electronics, M.I.T., January 15, 1972, pp. 250-256.

6. I. Howard, "A Directional Theory of Rule Application in Phonology," Ph.D. Thesis, Department of Modern Languages and Linguistics, M.I.T., September 1972 (unpublished).

7. R. P. V. Kiparsky, "Historical Linguistics," in W. O. Dingwall (Ed.), A Survey of Linguistic Science (American International Publishing Co., Washington, D.C., 1971), pp. 577-649.

8. M. Halle and K. N. Stevens, "A Note on Laryngeal Features," Quarterly Progress Report No. 101, Research Laboratory of Electronics, M.I.T., April 15, 1971, pp. 198-213.

9. I. Howard, op. cit., pp. 41 ff.

B. CLAUSE STRUCTURE AND THE PERCEPTUAL ANALYSIS OF SENTENCES

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 subject had to decide whether this word occurred in the sentence just presented, and indicate 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) $\underline{\qquad\quad X}_{\text{SUBORDINATE}}, \underline{\qquad}_{\text{MAIN}}$ After you read the fine print on the LEASE, check the tax clause carefully.

(2) $\underline{\qquad\quad}_{\text{SUBORDINATE}}, \underline{X\quad}_{\text{MAIN}}$ After you have read the fine print, the LEASE should be checked for tax clauses.

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

(4) $\underline{\quad\quad}_{\text{MAIN}}, \underline{X\qquad\quad}_{\text{SUBORDINATE}}$ You should read the fine print, after the LEASE has been checked for tax clauses.

(where "X" 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 telegraph 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 variables, and subjects by replications counted as the error term. In this design, the total variance in the data was estimated by three factors:

$$\underbrace{\text{row effect}}_{\substack{\text{due to surface} \\ \text{clause boundaries}}} + \underbrace{\text{column effect}}_{\text{due to clause order}} + \underbrace{\text{their interaction}}_{\text{due to kind of clause}}$$

The analysis revealed that probes from the first clause were recognized faster than probes from the second clause. (F = 10.828, p < .003, df = 1/47). Thus, the surface boundary effect was highly significant, but the dominance effect was not. (For clause order, F = .773; df = 1/47; and for the interaction of probe position x kind of clause, F = .201, 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 [[subordinate]... [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

1. T. G. Bever, J. R. Lackner, and R. Kirk, "The Underlying Structures of Sentences Are the Primary Units of Immediate Speech Processing," Perception Psychophys. 5, 225-231 (1969).

2. M. F. Garrett, Paper presented at the Midwestern Psychological Association Convention, Cincinnati, Ohio, April 1970.

3. D. Caplan, "Probe Tests and Sentence Perception," Ph.D. Thesis, Department of Linguistics, M.I.T., 1971.

4. J. A. Fodor, J. D. Fodor, M. F. Garrett, and J. R. Lackner (report of experiments now in progress, forthcoming).

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

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[1] has described.

Our proposal requires that we revise slightly the formalism proposed by Chomsky[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

$$(1) \quad \ldots \underline{\quad\quad}_{NP}[[-\text{unit}]]_{NP} \ldots$$

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

$$(2) \quad \ldots \underline{\quad\quad} \quad {}_{NP}\begin{bmatrix} [+\text{unit}] \\ \begin{bmatrix} \alpha F \\ \beta G \\ \vdots \end{bmatrix} \end{bmatrix}_{NP} \ldots$$

where $[F]$, $[G]$, etc. are selectional restriction features. Within this framework, the dummy symbol Δ stands for the feature $[+\text{unit}]$ without any extra selectional specification.

To give a concrete example, <u>frighten</u> will have the following contextual frame (see Chomsky[3]):

$$(3) \quad NP\begin{bmatrix} \begin{bmatrix} +unit \end{bmatrix} \\ \begin{bmatrix} +abstract \end{bmatrix} \\ \vdots \end{bmatrix}_{NP} VP\begin{bmatrix} \underline{\qquad} & NP\begin{bmatrix} \begin{bmatrix} +unit \end{bmatrix} \\ \begin{bmatrix} +animate \end{bmatrix} \\ \vdots \end{bmatrix}_{NP} \cdots \end{bmatrix}_{VP} \cdots$$

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

$$NP[\Delta]_{NP} \; VP[\underline{\qquad} NP[\Delta]_{NP} \cdots]_{VP} \cdots$$

The second line provides one of the selectional restrictions:

$$[+abstract] \underline{\qquad} [+animate]$$

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 <u>lexical transformation</u>):

$$T_1 \quad \underset{1}{NP} \underline{\qquad} \underset{2}{NP} \longrightarrow 3 \; 2 \; \emptyset$$
$$ \underset{3}{}$$

T_1 will operate on a string of the form

$$(4) \quad NP[\mu]_{NP} \; VP[\underline{\qquad} NP[\nu]_{NP} \cdots]_{VP} \cdots$$

to produce a string of the form

$$(5) \quad NP[\nu]_{NP} \; VP[\underline{\qquad} NP[[-unit]]_{NP} \cdots]_{VP} \cdots$$

Clearly, T_1 is the lexical equivalent of the syntactic transformation of Object Preposing. Another transformation which it will be useful to consider is

$$T_2 \quad \underset{1}{NP} \underset{2}{\quad\underline{\quad\quad}\quad X} \underset{3}{prep} \underset{4}{NP} \longrightarrow \emptyset \; 2 \; 3 \; 1$$

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, prep is by, T_2 will operate on a string of the form:

(6) $\quad _{NP}\textbf{[}\mu\textbf{]}_{NP} \; VP\textbf{[} \underline{\quad\quad} X \; \underline{by} \; _{NP}\textbf{[}\nu\textbf{]}_{NP} \cdots \textbf{]}_{VP} \cdots$

to produce a string of the form

(7) $\quad _{NP}\textbf{[}[-\text{unit}]\textbf{]}_{NP} \; VP\textbf{[} \underline{\quad\quad} X \; \underline{by} \; _{NP}\textbf{[}\mu\textbf{]}_{NP} \cdots \textbf{]}_{VP} \cdots$

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

Assuming Halle's theory of the lexicon,[1] 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}:

$$T_1^{-1} \quad \underset{1}{NP} \underset{2}{\quad\underline{\quad\quad}\quad} \underset{3}{NP} \longrightarrow \emptyset \; 2 \; 1$$

$$T_2^{-1} \quad \underset{1}{NP} \underset{2}{\quad\underline{\quad\quad}\quad X} \underset{3}{prep} \underset{4}{NP} \longrightarrow 4 \; 2 \; 3 \; \emptyset$$

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

(8) $\quad \phi = \{ \; _V\textbf{[}[\text{Adj}]+\underline{en}\textbf{]}_V, \; S_\phi, \; \Sigma_\phi \}$

This rule associates, e.g., black and blacken; S_ϕ and Σ_ϕ represent, respectively, the regular syntactic and semantic modification introduced by ϕ. Other derivational rules are:

(9) $\quad \Psi = \{ \; _A\textbf{[} [\text{Verb}]+\underline{able} \textbf{]}_A, \; S_\Psi, \; \Sigma_\Psi \}$

(10) $\quad \theta = \{ \; _A\textbf{[} [\text{Verb}]+\underline{ion}\textbf{]}_N, \; S_\theta, \; \Sigma_\theta \}$

Ψ relates, e.g., read and readable and θ, e.g., destroy and destruction. We shall not

give here the underlying phonological representations of the suffixes corresponding to Ψ and θ (nor do we state the fact, for instance, that the suffix _ion_ is often preceded by the affix _At_ (see Chomsky and Halle[5]). The bracketed structures showing up in the representations of ϕ, Ψ, and θ 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 ϕ, Ψ, and θ. Borrowing the term from Dell,[6] we call such rules ϕ, Ψ, and θ 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 _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) $d(x, y) = 1 - \dfrac{n}{N}$

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 _black_ and _blacken_ are no less strongly related than _destroy_ and _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 ϕ. It seems clear, though, that "distance" remains the natural and correct notion in all of these cases. It appears that the function _distance_ has simply to be made dependent on the particular transposition under consideration. Consider ϕ, for instance. One can very naturally define a "distance modulo ϕ" (written d_ϕ):

(12) $d_\phi(x, y) = 1 - \dfrac{n_\phi}{N}$

where n_ϕ is the number of features of y which can be deduced from features of x through the operation of ϕ, and N is as defined in (11). The distance d_ϕ 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) _black_ will be marked $[+\phi]$. Of course, the problem remains of determining n_ϕ. 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 $N - n_\phi$. Here again the mechanism is very classical and natural. In the lexicon, ϕ will be marked $[+T_1^{-1}]$ (the feature $[+T_1^{-1}]$ being an element of S_ϕ). 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 ϕ between x and y. Consider the pair (black, blacken). If black has the contextual frame

$$(13) \qquad {}_{NP}\!\left[\begin{array}{c} [+\text{unit}] \\ \left[\begin{array}{c} \alpha F \\ \beta G \\ \gamma H \\ \vdots \end{array}\right] \end{array}\right]_{VP}\!\left[\underline{\qquad} {}_{NP}[[-\text{unit}]]\ldots\right]\ldots$$

and blacken has the contextual frame

$$(14) \qquad {}_{NP}\!\left[\begin{array}{c} [+\text{unit}] \\ \left[\begin{array}{c} \ \\ \delta K \\ \epsilon L \\ \vdots \end{array}\right] \end{array}\right]_{VP}\!\left[\underline{\qquad} {}_{NP}\!\left[\begin{array}{c} [+\text{unit}] \\ \left[\begin{array}{c} \alpha F \\ \beta G \\ -\gamma H \\ \vdots \end{array}\right] \end{array}\right]\ldots\right]\ldots$$

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

$$(15) \qquad {}_{NP}[[+\text{unit}]]_{NP} {}_{VP}[\underline{\qquad} \ldots$$

Similarly, the features " $\underline{\qquad} [\alpha F]$" and " $\underline{\qquad} [\beta G]$" will count for 0. On the other hand, " $\underline{\qquad} [-\gamma H]$" is not deducible from $[\gamma H] \underline{\qquad}$, and hence will be counted. Clearly, certain selectional restrictions imposed by the subject of blacken, as well as the strict subcategorization ${}_{NP}[[+\text{unit}]]_{NP} {}_{VP}[\underline{\qquad}$ are also deducible from the syntactic properties of ϕ. That implies that to each feature i we must associate an insertion transformation u_i, and ϕ must be specified positively or negatively for each feature $[u_i]$. We shall not go into the details of such a system.[7]

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

$$(9) \qquad \Psi = \left\{ {}_A[\ [\text{Verb}]+\underline{\text{able}}]_A, \ S_\Psi, \ \Sigma_\Psi \right\}$$

In the pair (read, readable) the same selectional restrictions are imposed by the object

of <u>read</u> and the subject of <u>readable</u>. Moreover, <u>readable</u> has no direct object; clearly, S_Ψ contains the feature $[+T_1]$. We note that <u>readable</u> has an optional complement with the preposition <u>for</u> which imposes the same selectional restrictions as the subject of <u>read</u>:

(16)   This book is readable for most students.

This indicates that S_Ψ contains the feature $[\alpha T_2 \text{ (\underline{for})}]$, where α 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, Ψ has other remarkable properties. We observe that in order to enter the derivation Ψ 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:

$$[+\Psi] \longrightarrow \underline{\qquad}_{NP}[\ [+\text{unit}]\ ]_{NP}$$

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 (<u>perish</u>, <u>perishable</u>) or (<u>incline</u>, <u>inclinable</u> ("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 Ψ. It is clear, though, that the derivation involved has strong similarities with Ψ. There is a very straightforward way to formalize this intuition. Let us denote "$\circ$" 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 correlatives, we mark <u>perish</u> and <u>incline</u>

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

In other words, the degenerate transposition T_1^{-1} will apply first to a form like <u>perish</u> to make its contextual frame fit the structural description of Ψ; the distance between <u>perish</u> and <u>perishable</u> 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 $x \Longrightarrow y = x+\underline{able}$, 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 Ψ, namely the class containing such pairs as (<u>ski</u>, <u>skiable</u>) and (<u>swim</u>, <u>swimmable</u>).   In such pairs the place complement becomes the subject of the derived adjective.   In this case, we are led to posit the transformation:

$$T_3 \quad \text{------} \quad NP \quad \underset{2}{\underset{(place)}{prep}} \quad NP \longrightarrow 1 \quad 4 \quad \emptyset \quad \emptyset$$
$$\quad\quad\quad 1 \quad\quad 2 \quad\quad\quad 3 \quad\quad 4$$

and to mark <u>ski</u> and <u>swim</u> $[+\Psi \circ T_3]$.   This is essentially the approach adopted by Dell.[6]

   The notion of degenerate transposition has applications elsewhere in the lexicon. Consider, for instance, a verb such as <u>open</u> which, as J. Bowers[8] has shown,   enters 3 different contextual frames:

(18) $\underline{open}_1$ $NP\begin{bmatrix}\Delta\\\mu\end{bmatrix}_{NP} VP\begin{bmatrix}\text{------} & NP\begin{bmatrix}\Delta\\\nu\end{bmatrix}_{NP} & \text{with} & NP\begin{bmatrix}\Delta\\\pi\end{bmatrix}_{NP}\end{bmatrix}_{VP}$

   as in: John opened the door with a key

   $\underline{open}_2$ $NP\begin{bmatrix}\Delta\\\nu\end{bmatrix}_{NP} VP\begin{bmatrix}\text{------} & NP[[-unit]]_{NP} & \text{with} & NP\begin{bmatrix}\Delta\\\pi\end{bmatrix}_{NP}\end{bmatrix}_{VP}$

   as in: the door opened with a key

   $\underline{open}_3$ $NP\begin{bmatrix}\Delta\\\pi\end{bmatrix}_{NP} VP\begin{bmatrix}\text{------} & NP\begin{bmatrix}\Delta\\\nu\end{bmatrix}_{NP}\end{bmatrix}_{VP}$

   as in: the key opened the door

where μ, ν, and π are matrices of selectional features.   In order to account for the properties of <u>open</u> and of other similar items, we first define a set of <u>canceling transformations</u>:

$$e_1 \qquad \text{NP} \underset{1 \qquad 2}{\rule{2cm}{0.4pt}} \longrightarrow \emptyset \; 2$$

$$e_2 \qquad \underset{1 \qquad 2}{\rule{2cm}{0.4pt}\text{NP}} \longrightarrow 1 \; \emptyset$$

$$e_3 \qquad \underset{1 \qquad 2 \qquad 3}{\rule{2cm}{0.4pt}\text{NP} \;\; \text{PP}} \longrightarrow 1 \; 2 \; \emptyset$$

$$\vdots$$

etc.

Each e_j replaces a particular element in the contextual frame by $[-\text{unit}]$. It is easy to see that the distance between $\underline{\text{open}}_1$ and $\underline{\text{open}}_2$ is 0 modulo $T_1 \circ e_1$, and that the distance between $\underline{\text{open}}_1$ and $\underline{\text{open}}_3$ is 0 modulo $T_2^{-1} (\underline{\text{with}}) \circ e_1$. Thus, we shall mark $\underline{\text{open}}_1$: $[+T_1 \circ e_1]$, $[+T_2^{-1} \circ e_1]$. 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)   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 ($\underline{\text{eat}}_1$ (transitive), $\underline{\text{eat}}_2$ (intransitive)): $\underline{\text{eat}}_1$ is marked $[+e_2]$ and the distance between $\underline{\text{eat}}_1$ and $\underline{\text{eat}}_2$ is 0 modulo e_2.

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

References and Footnotes

1. M. Halle, "Prologomena to a Theory of Word Formation" (to appear in Ling. Inquiry).
2. N. Chomsky, Aspects of the Theory of Syntax (The M. I. T. Press, Cambridge, Mass., 1965).
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.
5. N. Chomsky and M. Halle, The Sound Pattern of English (Harper and Row, Publishers, Inc., New York, 1968).
6. F. Dell, "Les Règles Phonologiques Tardives et la Morphologie Dérivationelle du Français," Ph. D. Thesis, M. I. T., 1969 (unpublished).
7. Obviously, very heavy restrictions must be put on the u_i. 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 Ψ); otherwise, the whole system would be reduced to vacuity.
8. J. Bowers, "Grammatical Relations," Ph. D. Thesis, Department of Foreign Literatures and Linguistics, M. I. T., January 1972 (unpublished).

D. NONGLOBAL RULES IN KLAMATH PHONOLOGY

Mary-Louise Kean

1. Introduction

In several recent papers Kisseberth[1-3] has argued that to account for the morpho-phonemics and segmental phonology of Klamath, rules must apply cyclically. The analysis presented by Kisseberth relies on global rules (see Lakoff[4]), and necessitates violation of the principle of strict cyclicity (see Kean[5]). 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.[6]

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:[9]

(1)				
čwe:ka	'is tough'	snečwe:ka	(causative$_1$)	
Lo:pa	'eats soup'	snoLo:pa	(causative$_1$)	
pe:nhi	'is naked'	hespe:nhi	(causative$_2$)	
ci:ya	'stays	hisci:	(causative$_2$)	
twa:qa	'smears'	satwa:qa	(reflexive)	
plo:qa	'smear pitch on someone's head'	soplo:qa	(reflexive)	
to:ka	'hair falls out'	poto:ka	'pull hair out'	
Lo:la	'comes apart'	poLo:la	'pull apart'	
pe:wa	'bathes'	pepe:wa	(distributive)	
ma:s?a	'is sick'	mama:s?a	(distributive)	

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) [# sne [# čwe:k + a #] #]

[# hes [# [# pe:nhi #] #]

[# sa [# twa:q + a #] #]

[# po [# to:k + a #] #]

[# 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; čwe:ka is, itself, a well-formed word; therefore, there must be a structure [# čwe:k + 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 snečwe:ka.

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

(3)

paga	'smokes'	snapga	(causative₁)
ntopa	'spoils'	snontpa	(causative₁)
toqa	'is scared'	hostqa	(causative₂)
ltoqa	'thumps'	soltqa	(reflexive)
delo:ga	'attacks'	sedlo:ga	(reflexive)
kača	'cut off the head'	pakča	'pull off someone's head'
teka	'be in pieces'	petka	'pull off bit by bit'
kača	'cut off the head'	gwakča	'bite off the head'
tita	'open a bulbous object'	gwatta	'bite open a bulbous object'
qniya	'has an erection'	qniqnya	(distributive)
paga	'barks'	papga	(distributive)

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

(4) $\breve{V} \longrightarrow \emptyset \ / \ [\ \# \ C_1 \ V \ C_0 \ \# \ C_1 \underline{} C \ V \ X \ \#\# \ ]$

When a reduplicative prefix precedes a closed syllable with a short vowel, the vowel of that syllable does not delete but rather undergoes reduction.[10]

(5)

wejli	'lisps'	snewəjli	(causative₁)
qlin	'choke'	sniqlən	(causative₂)
bonwa	'drinks'	hosbənwa	(causative₂)
metgal	'carries a pack'	hesmətgal	(causative₂)
katsga	'tooth falls out'	pakətsga	'pull someone's tooth out'
qos	'sprain'	poqəsli:na	'sprain by pulling'
qlin	'choke'	qliqlən	(distributive)
pčin	'twist'	pčipčən	(distributive)

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

(6) $\breve{V} \longrightarrow ə \ / \ [\ \# \ C_1 \ V \ C_0 \ \# \ C_1 \underline{} C \ (C \ X) \ \#\# \ ]$

Vowel Deletion (4) and Vowel Reduction (6) are unorderable because their environments are complementary. Within the theory of Chomsky and Halle,[12] (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) $\underbrace{C_1 \ V \ C_0 \ \# \ C_1}_{1} \ \overset{\vee}{V} \ \underbrace{C \ \langle C \rangle \ X}_{3}$

$\qquad \qquad 1 \qquad \qquad 2 \qquad \quad 3$

$\qquad \qquad 1 \qquad \quad \langle \partial \rangle \qquad 3$

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) $\underbrace{C_1 \ V \ C_0 \ \# \ C_1}_{1} \ \overset{\vee}{V} \ \begin{Bmatrix} \langle C \ (C \ X) \rangle \\ \underbrace{C \ V \ X}_{} \end{Bmatrix}$

$\qquad \qquad 1 \qquad \qquad 2 \qquad \quad 3$

$\qquad \qquad 1 \qquad \quad \langle \partial \rangle \qquad 3$

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) $\overset{\vee}{V} \longrightarrow \partial \ / \ [\ \# \ C_1 \ V \ C_0 \ \# \ C_1 \ \_\_\_ \ X \ \#\# \ ]$

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

(10) $\partial \longrightarrow \emptyset \ / \ [\ \# \ X \ \# \ C_1 \ \_\_\_ \ C \ V \ Z \ \#\# \ ]$

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)

-ǎci:k-	'wring out'	pǎci:ka	'pulls and twists'
-odg-	'out of a container'	potga	'pull out of a container'
-ote:g-	'deep into'	gwote:ga	'bite deep into'
-akw-	'across'	ʔɔkwa	'puts a long object across'
-ebli	'back/again'	ʔebli	'bring a long object back'

Vowel-initial stems do not occur unprefixed: *ǎci: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 –ači:k–, then when prefixed by pV- it would be *piči:ka. The only way to account for pači:ka is to assume that the stem has an under-lying initial /a/ which is deleted by some rule.

Based on the fact that čwe:ka is a well-formed word, it was argued that the under-lying form of snečwe:ka is [# sne [# čwe:k + a #] #]. There is no form *ači:ka; there-fore, it might be argued that the underlying form of pači:ka is [# pa + ači:k + a #]. Accepting [# pa + ači: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 pači:ka is [# pa [# ači:k + a #] #], then there will be a consistent morphology. That there is no *ači:ka from [# ači: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) $\breve{V} \longrightarrow \emptyset$ / [# 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)   Vowel Reduction

$\breve{V} \longrightarrow ə$ / [# # 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)   Vowel Deletion

$ə \longrightarrow \emptyset$ / [# X # $\langle C_1 \rangle_\alpha$ ___ $\langle C\ V \rangle_\beta$ Z ##] $\alpha \supset \beta$

where Z may contain # boundaries.

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

(A)   ʔi– 'act on plural objects'

[# ʔi [# be:Liʼ + a #] #]	ʔibe:liʼa	'take care of plural objects'
[# ʔi [# peɔ̌q + a #] #]	ʔipɔ̌qa	'puts plural objects on the face'
[# ʔi [# dang + a #] #]	ʔidənga	'meet (usually prefixed by the reflexive)'
[# ʔi [# ačw + a #] #]	ʔičwa	'puts plural objects in the hair'

čoq- 'act with the buttocks'

[# čoq [# p̓eq̓ + a #] #]   čoqpq̓a   'puts the buttocks in someone's face'

[# čoq [# ew + a #] #]   čoqwa   'puts the buttocks in water'

[# čoq [# p̓e:s + p̓es ? + a #] #]   čoqp̓e:sp̓es ? a   'wriggles the buttocks around'

These data show that (13) and (14) are very general rules. The vowel of ?i- is always /i/[14] and the vowel of čoq- is always /o/, so in this respect neither of them is like the prefixes which have been discussed thus far. But both ?i- and čoq- 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 + ?mč #]   loq?əmč   'big old grizzly'

[# loq + ?m #]   loq?əm   'grizzly's'

[# čol? + s #]   člo?əs   'calf of the leg'

[# del?n + dk #]   del?əntk   'faced'

[# giw? + s #]   giw?əs   'pine squirrel'

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

(16) $\emptyset \longrightarrow \partial$ / [# X C ? ___ C_1 #]

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

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

[# s?ewan? + wapk #]   s?ewanwapk   'will give plural objects'

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

(18) Post-? Epenthesis

$\emptyset \longrightarrow \partial$ / [# 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?əlga   'calls (distributive)' from [# ?e [# ?elg + a #] #]

čol?a   'has a cramp in the leg'

s?o:ga   'blue crane'

?ak?aka   'stutters'

Consider now the following items.

(20)   [# so [# ʔodiːl + a #] #]   soːdiːla   'puts plural objects underneath'

      [# ʔa [# ʔalaːY + a #] #]   ʔaːlaːYa   'shows (distributive)'

      [# si [# ʔimaːw̃ + a #] #]   siːmãːw̃a   'adds one amount of a substance to another'

      [# si [# ʔiỹoːt + a #] #]   siːyoːta   'trade plural objects'

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

    There are no cases of /ʔ/ in the environment V___C cited by Barker.[7,8] 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 /ʔ/.[16]

(21)   V   ʔ   C

      1   2   3 ⟶

$$\begin{bmatrix} 1 \\ +\text{long} \end{bmatrix} \quad \varnothing \quad 3$$

(22)   [# ʔa [# ʔalaːY + a #] #]

    ʔa   ʔəlaːY   a   Vowel Reduction (13)

    ʔa   ʔ laːY   a   Vowel Deletion (14)

    ʔaː   laːY   a   Rule (21)

    [# so [# ʔodiːl + a #] #]

    so   ʔədiːl   a   Vowel Reduction (13)

    so   ʔ diːl   a   Vowel Deletion (14)

    soː   diːl   a   Rule (21)

    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 [# ʔo [# odiːl + a #] #] #] #]

    so   sə   ʔə   ədiːl   a   Vowel Reduction (13)

 * so   s   ʔə   diːl   a   Vowel Deletion (14)

        not applicable   Rule (21)

The correct surface form of (23) is sosoːdiːla, '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 -odiːla and from - ʔo- 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[# ʔo[#odiːl+a#]#]#]#] yields the correct output.

(24)   [# so [# so [# ʔo [# odiːl + a #] #] #] #]

				1st Cycle
	ʔo	ədiːl	a	(13)
	ʔo	diːl	a	(14)
				2nd Cycle
so	ʔə	diːl	a	(13)
so	ʔ	diːl	a	(14)
soː		diːl	a	(21)
				3rd Cycle
	not applicable			(13)
	soːsoːdiːla			

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

(25)

wipga	sniw̌ɔpga	snisnwəpgis
'escapes'	(causative$_1$)	(distributive-causative noun)
peːwa	hespeːwa	hehəspeːwa
'bathes'	(causative$_2$)	(distributive-causative)
daqča	sadəqča	sasdəqča
'scratches someone'	(reflexive)	(distributive-reflexive)
qǒča	poqča	popəqča
'bends'	'pulls and bends out of shape'	(distributive)

If Vowel Reduction and Vowel Deletion applied simultaneously to their possible environments, then [# po [# po [# qǒč + a #] #] #] would be realized as *popqča and not popəqča. If these rules apply cyclically, the derivation of popəqča is easily accounted for: on the

first cycle, [# po [# q̓oč̌ + a #] #], Vowel Reduction and Vowel Deletion apply to yield
[# po [# q̓č̌ + a #] #]; on the second cycle, [# po [# po # q̓č̌ + a ##] #], Vowel Reduction
applies but Vowel Deletion cannot apply because its open syllable environment is not met,
and pop ə q̌ča 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., –odi:la in (24)
and –q̓oča above.

4. Epenthesis

When a reduplicative prefix precedes a sequence of the form $C\breve{V}\left\{\begin{matrix}w\\y\end{matrix}\right\}C$, we find, on
the surface, a "vocalized glide."

(26)   ňoylga   'is numb'   snonǰi:lga   (causative$_1$)
       q̓ayLy̓a   'puts on a belt' hasq̓i:Ly̓a   (causative$_2$)
       siwga   'kills'   hiso:ga   (reflexive)
       pewq̓ya   'embraces'   sepo:q̓ya   (reflexive)
       siwga   'kills'   siso:qa   (distributive)
       gayk̓a   'is silly'   gagi:ka   (distributive)

There are several ways in which these data might be accounted for. One might argue
that when a vowel-$\left\{\begin{matrix}w\\y\end{matrix}\right\}$ sequence is preceded by a reduplicative prefix, the vowel assim-
ilates to the glide and becomes long.

(27) $V \longrightarrow \begin{bmatrix} +\text{long} \\ +\text{high} \\ \alpha\text{back} \end{bmatrix} \quad / \quad [\ \# \ C_1 \ \ V \ \ C_0 \ \# \ C_1 \ \underline{\hspace{1cm}} \begin{bmatrix} +\text{son} \\ +\text{high} \\ \alpha\text{back} \end{bmatrix} \ \ C \ \ X \ \#\# \ ]$

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 moti-
vated as the derivation in (28) illustrates.

(28)   [# wo [# wos + a #] #]   'fears (distributive)'
           wo   w s   a   Vowel Reduction (13)
           wo   w s   a   Vowel Deletion (14)
           wo: s   a   Glide Lengthening/Deletion

Consider now these data.

(29)   čonwa   'vomits'   čono:ye:ga   'starts to vomit'
                                           (čonw + ye:g + a)
                                           čono:ňapga   'feels like vomiting'
                                           (čonw + ňapg + a)
       somalw̓a   'writes'   somalo:ye:ga   'starts to write'
                                           (somalw + ye:g + a)

smͻqya	'has a mouthful'	smͻqi:tk	(adjectival)
		(smͻqy̆ + tk)	
mbotẙa	'wrinkles'	mbodi:tk	(adjectival)
		(mbody̆ + tk)	

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-$\left\{\begin{matrix} w \\ y \end{matrix}\right\}$ sequence. Therefore, if (27) is to be maintained, a second rule of vocalization such as (30) will be needed.

(30) $\begin{bmatrix} -\text{syl} \\ +\text{son} \\ +\text{high} \end{bmatrix} \longrightarrow \begin{bmatrix} +\text{syl} \\ +\text{long} \end{bmatrix}$ / [# X C ___ C 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$\left\{\begin{matrix} w \\ y \end{matrix}\right\}$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) [# bonw + s #]   bonwəs   'drink'

   [# delwg + s #]   delwəks   'attack'

   [# sgoyw [# alčwi #] #]   sgoywəlčwi   'send someone right up to'

   [# sʔaywg + s #]   sʔaywəgs   'knowing'

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

(32) ∅ ⟶ ə / [# X V C w ___ C (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) [# čalw + ys #]   *čalwəys

   [# ʔiww + ys #]   *ʔiwwəys

The surface forms in (33) derived by rule (32) are incorrect. They should be thus.[20]

(34) [# čalw + ys #]   čalwis   'rotten fish'

   [# ʔiww + ys #]   ʔiwwis   '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 $\vartheta \left\{ \begin{matrix} w \\ y \end{matrix} \right\}$ 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 inde- pendently motivated rule. Accepting this proposal leads to derivations such as these:

(35)   [# si [# siwg + a #] #]   'kills (distributive)'

      si   sǝwg   a   Vowel Reduction (13)

      si   so:g   a   Vocalization

   [# ga [# gayk̚ + a #] #]   'is silly (distributive)'

      ga   gǝyk̚   a   Vowel Reduction (13)

      ga   gi:k̚   a   Vocalization

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

(34')   [# čalw + ys #]   'rotten fish'

      čalw ǝys   Rule (32)

      čalw i   s   Vocalization

   [# ʔiww + ys #]   'back of the knee'

      ʔiww ǝ ys   Rule (32)

      ʔiww i   s   Vocalization

(36)   [# ge̤ [# elwy + bg + a #] #]   gelwipga   'goes by fire'

    [# slo [# slo:lw + ys #] #]   sloslo:lwis   'flute player'

    [# spel + w + ys #]   spelwis   'index finger'

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

(37)   [# ndo [# ogǝ + ys #] #]   ndogi:s   'hawk'

    [# go̤ [# gwo # ogǝ + ys #] #] #]   gogo:gis   'habitual biter'

    [# sčilik̚ǝ + ys #]   sčiliki:s   '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 con- sonant clusters and interact with vocalization. Consonant clusters of the form $C \begin{bmatrix} +son \\ +cons \end{bmatrix} C_2$ are broken up by an epenthetic schwa before the sonorant.

(38)   [# ʔi + tn + bli #]   ʔitəmbli   'attaches plural
                                                                      objects again'

       [# wbe + čn + bga #]   wbecəmpga   'is throwing plural
                                                                      objects away'

       [# si [# ʔi [# adgl [# ebli + wk #] #] #] #]   siʔədgəlblik   'in order to pick
                                                                        itself back up'

Three member clusters with a medial sonorant are not broken up. Thus we find <u>ʔesnka</u>, 'weeps hard', and not * <u>ʔesənka</u>.

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

(39)   [# hon [# awl [# elg̣ + a #] #] #]   'flies up'
                                                     1st Cycle

                   awl   əlg̣   a   Vowel Reduction (13)
                   awl   lg̣   a   Vowel Deletion (14)
                   awəl   lg̣   a   Epenthesis

           hon   əwəl   lg̣   a   2nd Cycle
                                                     Vowel Reduction (13)
           hon   wəl   lg̣   a   Vowel Deletion (14)

(40)   [# nčiw [# awl [# elg̣ + a #] #] #]   'pops up'
                                                     1st Cycle

                   awl   əlg̣   a   Vowel Reduction (13)
                   awl   lg̣   a   Vowel Deletion (14)
                   awəl   lg̣   a   Epenthesis

                                                     2nd Cycle
           nčiw   əwel   lg̣   a   Vowel Reduction (13)
           nčiw   wəl   lg̣   a   Vowel Deletion (14)

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

(41)   Sonorant Cluster Rule

$$\emptyset \longrightarrow \text{ə} \;/\; [\; \# \; X \; C \; \underline{\quad\quad} \begin{bmatrix} +son \\ +cons \end{bmatrix} C_2 \; Y \; \# \;]$$

As the data in (39) and (40) show, rule (41) bleeds the rules which give vocalized glides. Word-final C $\left\{\begin{smallmatrix} l \\ m \end{smallmatrix}\right\}$ 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'

[# s ʔo: [# awl #] #]	s ʔo:wəl	'put a plate on top of'
[# spi [# adgl #] #]	spidgəl	'drags up'
[# koml #]	komǝl	'pelican'

Word-final clusters ending in /n/ are not subject to epenthesis.

(43) [# teyn #]   teyn   'new(ly)'

  [# tawn #]   tawn   'town'

To account for the data in (42), rule (44) is necessary.

(44)   Final /l/ and /m/

$$\emptyset \longrightarrow ə \ / \ [\ \# \ X \ C \ \_\_\_ \left\{ \begin{matrix} l \\ m \end{matrix} \right\} \# \ ]$$

That this rule is restricted to final clusters is evident by comparing komǝl, 'pelican', with komla:k, 'little pelican', and tgalǝm, '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 *snogwǝk; however, [# snog + wk #] is realized as snogo: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 snogo:k.

(45)   Idiosyncratic /w/

  $$\emptyset \longrightarrow ə \ / \ [\# \ X \ V \ [+son] \ w \ \_\_\_ \ C \ (C \ X) \ \#]$$

  Consider now these data.

(46)   [# mpaq [# awl #] #]   mpaqwǝl   'dries up on top'

  [# ngat [# awl #] #]   ngatwǝl   'jump up on top'

  [# w + q̓ot̓ [# awl #] #]   wq̓otwǝl   'makes a knot on top'

  [# peč̌ [# awl #] #]   peč̌wǝl   'puts a foot on top'

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)   [# s ʔo:wy + dk #]   s ʔo:widk   'having passed a tray'

  [# sney + ys #]   sneyi:s   'blackjack duck'

  [# Wal + ys #]   Wali:s   'cliff'

Consider now the paradigm:

(48)   [# ʔi [# iwy̓g + a #] #]   ʔiwi:ga   'put plural objects into'

  [# ʔi [# iwy̓g #] #]   ʔiwyǝq   'put in plural objects'

  [# ʔi [# iwy̓g + bli #] #]   ʔiwyǝqbli   'puts plural objects back in'

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

(49)   Idiosyncratic /y/

$$\emptyset \longrightarrow \partial \; / \; [\; \# \; X \; \; V \; [+son] \; y \; \underline{\quad} \begin{bmatrix} +cons \\ +back \end{bmatrix} (C \; Z) \; \# \;]$$

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) $\emptyset \longrightarrow \partial \; / \; [\; X \; \; V \; \; C \; \underline{\quad} \begin{Bmatrix} w \\ y \end{Bmatrix} C_1 \; \; Z \;]$

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

(51)   [# slankʷws +ksi #]   slankoski   'Bridge Place'

      [# sasalgy [# odg + a #] #]   sasalgitga   'been quarreling'

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

(52) $\emptyset \longrightarrow \partial \; / \; [\; X \; \; C \; \underline{\quad} \begin{Bmatrix} w \\ y \end{Bmatrix} C \; \; Z \;]$

Rule (52) fails to account for these data.

(53)   [# dewy #]   dewi: 'shoot a bow and arrow'

      [# lagy #]   lagi: 'misses someone'

      [# mbely #]   mbeli: 'is cross-eyed'

      [# nidw #]   nido: 'guesses'

      [# spony #]   sponi: '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)   Pre-Glide Epenthesis

$$\emptyset \longrightarrow \partial \; / \; [\; \# \; X \; \; C \; \underline{\quad} \begin{Bmatrix} w \\ y \end{Bmatrix} (C \; \; Z) \; \# \;]$$

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).

(45) $\emptyset \longrightarrow \partial$ / [# X V [+son] w ___ C (C Z) #]

(49) $\emptyset \longrightarrow \partial$ / [# X V [+son] y ___ $\begin{bmatrix} +cons \\ +back \end{bmatrix}$ (C Z) #]

(54) $\emptyset \longrightarrow \partial$ / [# X C ___ $\begin{Bmatrix} w \\ y \end{Bmatrix}$ (C Z) #]

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)   [# ʔi [# adg + bli #] #]   ʔidgəbli   'takes plural objects out of a container again'

       [# s ʔeqg [# odg + a #] #]   s ʔeqgətga   'been saying goodbye to someone'

       [# lo [# oc̆p + bli #] #]   loc̆pəbli   '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   wəyasg   ys   Vowel Reduction (13)
       has   w yasg   ys   Vowel Deletion (14)
       has   əw yasg   əys   Pre-Glide Epenthesis (54)
       has   o: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 # dəwy ##].   Rule (14) cannot apply to [# de # dəwy ##], 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   dəwy   Vowel Reduction (13)
       not applicable   Vowel Deletion (14)
    * de   dəwəy   Pre-Glide Epenthesis (54)

The only way to account for <u>dedwi</u> is to have Pre-Glide Epenthesis apply before Vowel Deletion.

(58)   [# de [# dewy #] #]

	dewəy	Pre-Glide Epenthesis (54)
de	dəwəy	Vowel Reduction (13)
de	dwəy	Vowel Deletion (14)
de	dwi	Vocalization

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)   [# has [# waẙasg + ys #]

		1st Cycle
	waẙasg əys	Pre-Glide Epenthesis (54)
		2nd Cycle
has	wəẙasg əys	Vowel Reduction (13)
has	w ẙasg əys	Vowel Deletion (14)
has	əw ẙasg əys	Pre-Glide Epenthesis (54)
has	o: ẙasg is	Vocalization

(60)   [# de [# dewy #] #]

		1st Cycle
	dewəy	Pre-Glide Epenthesis (54)
		2nd Cycle
de	dəwəy	Vowel Reduction (13)
de	d wəy	Vowel Deletion (14)
de	d wi	Vocalization

In Kean[5] it was argued that cyclic phonological rules must conform to the principle of strict cyclicity.

(61)   Principle of Strict Cyclicity

On any cycle A no cyclic rule may
apply to material within a previous
cycle B without making crucial use
of material uniquely in A.

The principle of strict cyclicity provides an explanation of why [# ñiq [# awl [# eĺg [# obg + a #] #] #] #] is realized as <u>niqwəllqpga</u>, 'keeps a hand raised'.

(62) [# nìq [# awl [# èlg [# obg + a #] #] #] #]

					1st Cycle
					2nd Cycle
		èlg	əbg	a	Vowel Reduction (13)
		elg	bg	a	Vowel Deletion (14)
					3rd Cycle
	awl	ə̀lg	bg	a	Vowel Reduction (13)
	awl	l̀g	bg	a	Vowel Deletion (14)
	awəl	l̀g	bg	a	Sonorant Cluster (41)
					4th Cycle
nìq	əwəl	l̀g	bg	a	Vowel Reduction (13)
nìq	wəl	l̀g	bg	a	Vowel Deletion (14)
	niqwəllqpga				Other Rules

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-glide sequences vocalize as long vowels in the environment VC___.

(63)   [# dewy #] → [# dewəy #] → dewi: 'shoot a bow and arrow'
[# mbely #] → [# mbeləy #] → mbeli: 'is cross-eyed'
[# tawy + s #] → [# tawəy + s #] → tawi:s   'curse'
[# nidw #] → [# nidəw #] → nido: 'guesses'
[# delwg + s #] → [# deləwg + s #] → delo:ks   'to attack'

In the environment V:C___, schwa-glide sequences vocalize as short vowels.[21]

(64)   [# loto:wy #] → [# loto:wəy #] → loto:wi   'gives an arm-load of objects'
[# b + se:y + yb #] → [# b + se:y + əyb #] → bse:yip   'uncle'
[# qdo:č + wk #] → [# qdo:č + əwk #] → qdo:čok   'because of rain'
[# me:qy + s #] → [# me:qəy + s #] → me:qis   'cry-baby'

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

(65)
$$\underbrace{\begin{matrix} V \\ [\alpha long] \end{matrix} \quad C}_{} \quad \text{ə} \quad \begin{bmatrix} +son \\ +high \end{bmatrix} \quad X$$

$$\begin{matrix} 1 & 2 & 3 & 4 \end{matrix} \longrightarrow$$

$$\begin{matrix} 1 & \emptyset & \begin{bmatrix} +syl \\ -\alpha long \end{bmatrix} & 4 \end{matrix}$$

In the environment $[\# \ X \ \# \ C_1 \ \underline{\hspace{1cm}} \ C_1 \ V \ Z \ \#\#]$, a schwa-glide sequence is realized as a long vowel.

(66)   [# sne [# nti̯w + l̯g + a #] #]   'drops'

       sne   ntə̯w   lg   a

          snentoːlga

    [# do [# okc̯w + wabg #] #]   'will fall into water headfirst'

       do   kc̯əw   wabg

         dokc̯oːwapk

    [# qba [# qbat̯y + wabg #] #]   'will wrap their legs around something'

       qba   qbt̯əy   wabg

         qbaqbtiːwapk

    [# hos [# qoẏg + a #] #]   'introduces someone'

       hos   qəẏg   a

         hosqiːga

    [# sʔo [# sʔoẏsʔ + a #] #]   'are thin (distributive)'

       sʔo   sʔəẏsʔ   a

         sʔosʔiːsʔa

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

(67) $\underbrace{X \# C_1}_{1} \quad \underset{2}{\text{ə}} \quad \underset{3}{\begin{bmatrix} +son \\ +high \end{bmatrix}} \quad \underbrace{C_1 \ V \ Z}_{4} \longrightarrow$

      $1 \quad \emptyset \quad \begin{bmatrix} +syl \\ +long \end{bmatrix} \quad 4$

In all other environments, schwa-glide sequences are realized as short vowels.[22]

(68)   [# de [# dewy #] #]   'shoot a bow and arrow'

      de   dwəy

       dedwi

    [# si [# nidw #] #]   'make an estimate of each other'

      si   ndəw

       sindo

[# slan [# akw + s #] #]   'bridge'

    slan   kəw s

        slankos

(69)   [# ge [# elwy [# obg + a #] #] #]   'visits'

    ge   lwəy   bg   a

        gelwibga

[# sasalky̆ [# odg + a #] #]   'been quarreling'

    sasalkəy̆   dg   a

        sasalkidga

The reason that (67) does not apply to the words in (68) is that there is no $-C_1V$ following the schwa-glide sequence. Rule (67) does not apply in (69) because a #-boundary falls within the $-C_1V$ condition and there is no provision in (67) for the intrusion of such a boundary.[23]

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) $\underbrace{X\ C}\ \partial\ \begin{bmatrix} +son \\ +high \end{bmatrix}\ Z$

    1   2   3   4

    1   $\emptyset$ $\begin{bmatrix} +syl \\ -long \end{bmatrix}$ 4

The rules of vocalization are, necessarily, post-cyclic. If they applied cyclically [# de [# dewy #]] would be realized as <u>dedwi:</u> and [# slan [# akw + s #] #] would be realized as <u>slanko:s.</u>

(71)   [# de [# dewy #] #]   'shoot a bow and arrow'
                                    1st Cycle
        dewəy   Pre-Glide Epenthesis (54)
        dewi: Vocalization (65)
        _____
                                    2nd Cycle
    de   dəwi: Vowel Reduction (13)
*   de   dwi: Vowel Deletion (14)

[# slan [# akw + s #] #]			'bridge'	
			1st Cycle	
	akəw	s	Pre-Glide Epenthesis (54)	
	ako:	s	Vocalization (65)	
			2nd Cycle	
slan	əko:	s	Vowel Reduction (13)	
* slan	ko:	s	Vowel Deletion (14)	

7. Kisseberth's Rules for Klamath

Let us turn now to the analysis of these data presented by Kisseberth.[2,3] Kisseberth proposes that the underlying forms of the reduplicative prefixes are as given in (K-1).

(K-1) snV*   causative$_1$

hV*s   causative$_2$

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.[24]

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.[25]

(K-4) Vowel Deletion

Short Vowels simply drop after being
copied onto a preceding pro-vowel [V*].[26]

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'a	'take care of plural objects'
$[\# \ ?i \ [\# \ p\overset{\circ}{e}\overset{\circ}{q} + a \ \#] \ \#]$	?ip\overset{\circ}{q}a	'puts plural objects on the face'
$[\# \ ?i \ [\# \ dang + a \ \#] \ \#]$	?id nga	'meet (usually prefixed by the reflexive)'
$[\# \ ?i \ [\# \ a\overset{v}{c}w + a \ \#] \ \#]$	?i\overset{v}{c}wa	'puts plural objects in the hair'

$\overset{\vee}{c}$oq- 'act with the buttocks

$[\# \ \overset{\vee}{c}oq \ [\# \ p\overset{\circ}{e}\overset{\circ}{q} + a \ \#] \ \#]$	$\overset{\vee}{c}$oqp\overset{\circ}{q}a	'puts the buttocks in some-one's face'
$[\# \ \overset{\vee}{c}oq \ [\# \ ew + a \ \#] \ \#]$	$\overset{\vee}{c}$oqwa	'puts the buttocks in water'
$[\# \ \overset{\vee}{c}oq \ [\# \ p\overset{\circ}{e}{:}s + p\overset{\circ}{e}s? + a \ \#] \ \#]$	$\overset{\vee}{c}$oqp\overset{\circ}{e}{:}sp\overset{\circ}{e}s?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 -CV̌CC- 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-glide 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 [# ʔi [# iwy̆g #] #] as *ʔiwi: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 VC___ and VC_1___CV. The $V:C_0$___ environment suggests that [#c̆a:yc̆a:ys#] might go to *[# c̆a:ic̆a:is #] in the derivation of c̆a:yc̆a:ys, 'sleet'. The C_2___C_2 environment predicts that [# sne [# ntiw + lg + a #] #] will be realized as *snentolga and not as snento:lga, '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.

$$(K\text{-}6) \quad \begin{matrix} V \\ [+\text{long}] \end{matrix} \longrightarrow [-\text{long}] \;/\; \left\{ \begin{matrix} \begin{matrix} V \\ [+\text{long}] \end{matrix} C_0 \\ \\ C_2 \underline{\quad} \left\{ \begin{matrix} C_0 \,\# \\ C_2 \end{matrix} \right. \end{matrix} \right.$$

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 [# ntiw + 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

1. C. W. Kisseberth, "On the Alternation of Vowel Length in Klamath: A Global Rule," to appear in Issues in Phonological Theory, Proc. Urbana Conference on Phonology, April 23-24, 1971.

2. C. W. Kisseberth, "Cyclical Rules in Klamath Phonology," Ling. Inquiry 3.1, 3-34 (1972); also "A Further Argument for the Cycle in Klamath Phonology" (unpublished Ms).

3. C. W. Kisseberth, "The 'Strict Cyclicity Principle': the Klamath Evidence" (unpublished Ms, 1972).

4. G. Lakoff, "Global Rules," Language, Vol. 46, 1970.

5. Mary-Louise Kean, "Strict Cyclicity and the Preservation of Structure in Phonology" (unpublished; available on ditto, 1971).

6. The sources for the data discussed here are Barker,[7,8] 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.

7. M. A. R. Barker, Klamath Dictionary, Vol. 31, University of California Publications in Linguistics (Berkeley and Los Angeles, 1963).

8. M. A. R. Barker, Klamath Grammar, Vol. 32, University of California Publications in Linguistics (Berkeley and Los Angeles, 1964).

9. The forms cited in (1) are in the indicative which generally has a $\emptyset$ realization after morpheme-final vowels $\underline{w}$, $\underline{y}$, and $\underline{n}$, and which is realized as $-\underline{a}$ elsewhere. The causative prefixes differ in degree, causative$_1$ 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[11] 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/. Taken seriously, Kisseberth's treatment suggests that the underlying vowels of the words in (5) first neutralize to /a/, a low back vowel, and then the /a/ reduce to schwa. One might argue that by neutralizing the vowels of (5) to /a/ it is possible to capture the generalization that schwas are derived from /a/. As the words in (5) show, however, this is a spurious generalization.

11. M. A. R. Barker, Klamath Grammar, op. cit., pp. 32-34.

12. N. Chomsky and M. Halle, The Sound Pattern of English (Harper and Row Publishers, Inc., New York, 1968).

13. The need for the condition on Z in (13) and (14) is based on examples like (23).

14. ʔi- appears as ʔe- before en, 'action away', as in ʔena, 'take plural objects away', and ebg, 'action toward', as in ʔepga, 'bring plural objects'. Elsewhere it is always ʔi-.

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

teka	'burns'	tekteka	(intensive)
dopa	'boils'	dopdopa	(intensive)
bema	'is confused'	be:mbema	(strong intensive)

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[2] that rule (21) should be combined with the rule which deletes /ʔ/ from the environment C___C. I think such collapsing is a mistake and that the deletion of /ʔ/ 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.[17]

17. C. W. Kisseberth, "An Argument against the Principle of Simultaneous Application of Rules," Ling. Inquiry 3.3, 392-396 (1972).

18. The formulation of a deletion rule such as would be required by a solution using only rule (30) is suggested in Kean.[19]

19. Mary-Louise Kean, "Are Glottal Stop and h Sonorants?," Quarterly Progress Report No. 106, Research Laboratory of Electronics, M.I.T., July 15, 1972, pp. 151-159.

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: [# sʔi [# sʔin + ys #] #] sʔisʔi:s, 'one who habitually has coitus'. Presumably, sʔisʔi: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.

24. C. W. Kisseberth, "Cyclical Rules in Klamath Phonology," op. cit., p. 6.

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

26. C. W. Kisseberth, "Cyclical Rules in Klamath Phonology," op. cit., p. 16.

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.[28]

28. C. W. Kisseberth, "Cyclical Rules in Klamath Phonology," op. cit., pp. 10-16.

29. Ibid., p. 14.