

## Interacting Processes

**Linear rule ordering.** In the taxonomic model, the grammar of a language is a statement of relations between the significant levels of analysis, so for example phonetic [p<sup>h</sup>] in English relates to the phoneme /p/, which relates to a morphophoneme ||p||. This approach only has ‘intermediate’ stages in a derivation by defining special levels — the surface, phonemic, and morphophonemic levels, and within the set of statements which relate levels, there is (classically) no order in which statements apply: mapping between levels is direct. Still, the efficacy of ordered rules was recognised in some structuralist analyses, for example Bloomfield in his analysis of Menomini (Bloomfield 1939) says “If one starts with the basic forms and applies our statements (§§10 and following) in the order in which we give them, one will arrive finally at the forms of words as they are actually spoken”. See Bever (1967) for discussion of the similarities between Bloomfield’s description of Menomini and the theory of generative phonology, and Kenstowicz (1977) for an overview of pre-generative views on rule ordering.

The formal character of rule ordering in generative phonology is stated in Chomsky & Halle (1968) as a ordered list (like the integers 1, 2, 3, 4...), specifically as a linear order, a technical concept discussed in Wall (1972) and similar textbooks. A review of certain formal properties of relations, some of which you are probably familiar with, will be helpful.

*REFLEXIVE*: relation P is reflexive iff for all x, xPx. [e.g. ‘is the same as’]

*IRREFLEXIVE*: relation P is irreflexive iff no x P’s itself. [e.g. ‘is different from’]

*SYMMETRY*: relation P is symmetrical just in case for all x and y, if xPy then yPx. [e.g. ‘is related to’]

*ASYMMETRY*: relation P is asymmetrical iff for any x,y such that xPy it is not the case that yPx. [e.g. ‘is a parent of’]

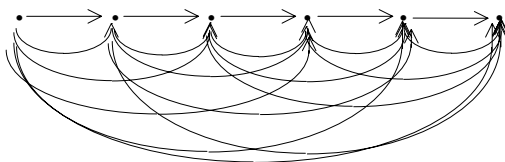
*ANTISYMMETRY*: relation P is antisymmetrical iff for any x,y such that xPy, if yPx then x=y. [e.g. ‘greater than or equal to’]

*TRANSITIVITY*: relation P is transitive iff it is that case that the conjunction (xPy) and (yPz) entails (xPz). [e.g. ‘older than’]

*INTRANSITIVITY*: relation P is intransitive iff it is the case that if (xPy) and (yPz) are true, then (xPz) is not true. [e.g. ‘immediately precedes’]

*CONNEXITY*: relation P is connex iff for all x and y, either (xPy) or (yPx).

A strong linear ordering of the form (A, B, C, D...) has four formal properties: it is transitive, irreflexive, asymmetric, and observes connexity. At a more intuitive level, this means that if A precedes B and B precedes C, then A precedes C; no rule precedes itself; if A precedes B then A can’t follow B; finally, all rules are ordered. These relations can be graphed as:



where each dot represents a rule and every line with an arrow represents a specific precedence relation. In addition, rules apply Markovianly, which means that a rule only has access to the form of a phonological string as it exists at the point where the rule applies: the first rule sees only the underlying form, the second rule only sees the output of the first rule, and so on.

**Feeding & Bleeding.** Kiparsky (1968) defines four fundamental relations which have played a central role in discussions of ordering. One relation, termed **feeding**, arises when A precedes B and application of A creates new strings that can undergo B, which would not have existed except by applying the first rule A. Glide Formation in Kikamba turns *e* into *y* before a vowel, and palatalization changes *ky* into *č*. Glide Formation creates instances of *y* not underlyingly present, and derived *y* conditions the palatalization rule: /kokéá̃syǎ/ first becomes *kokyáá̃syǎ*, then [kočáá̃syǎ] by palatalization, conditioned by this derived *y*. **Counterfeeding** is where A precedes B, and the output of B satisfies the requirements of A, but rule A does *not* apply to the output of rule B. An example of that relation is Lomongo, where *b*-deletion deletes *b* between vowels, and *o* before another vowel becomes *w*. However, the sequence *oi* brought into existence by *b*-deletion does not undergo Glide Formation, so /obina/ surfaces as [oina], not \*[wina]: *b*-deletion counterfeeds Glide Formation.

A **bleeding** relation is where the input to rule A could undergo both A and B, but the output of A can no longer undergo rule B — applying A destroys the structure necessary for B. This mode of application is illustrated in Lithuanian, where Epenthesis and Voicing Assimilation could both apply to underlying /at-duoti/, but in fact epenthesis applies first to give *atiduoti*, so the epenthetic vowel makes it impossible for voicing assimilation to apply. The opposite relation, **counterbleeding**, is found in Armenian, where an obstruent first assimilates to the following consonant in voicing and aspiration so /k-b<sup>h</sup>ieřiem/ becomes *g<sup>h</sup>-b<sup>h</sup>ieřiem*, but the consonants are then separated by epenthesis giving [g<sup>h</sup>ə-b<sup>h</sup>ieřiem] ‘I will carry’. Counterbleeding can be defined negatively as “if the rules were in the opposite order, the relation would be bleeding”.

In Kiparsky’s original proposal, it was held that certain ordering relations are more natural or “unmarked” — feeding and counterbleeding are argued to be the less marked orders. The functional characteristic that explains this partitioning of rules is that feeding and counterbleeding orders maximize the opportunity for each rule to apply.

**Combinatorics and the generative power problem.** Rule ordering has been considered to be a powerful descriptive device, one that allows perhaps too many languages to be theoretically describable. If a language has 5 rules, how many ways can those rules be ordered? Mathematical combinatorics provides  $5!$  ( $5 \times 4 \times 3 \times 2 \times 1$ ) = 120 possible permutations of just 5 rules, and over 87 billion arrangements of 14 rules — many languages are known to have rule inventories which number in the dozens, so obviously a huge number of grammars can be constructed if rule ordering is free. This ability to arrange rules in any permutation thus results in a considerable disparity between descriptive potential and actual languages, and points to an area where the theory may be empirically inadequate since it predicts many things that do not happen. Many proposals were advanced in the two decades following 1968 which, in one form or another, addressed the issue of the generative power of rule ordering.



subsequent work pursued that approach to ordering. (See Trommelen & Zonneveld 1978 for critical discussion of the Unordered Rule Hypothesis). In the KSN theory, all rules apply simultaneously to a string, and the results of rule application are continuously resubmitted to the phonology until no more rules are applicable. An example of the operation of this theory is an assumed feeding relationship in Finnish between a rule deleting  $\gamma$  between vowels and a diphthongization rule where /ee/ → [ie]. The feeding application of the rules is illustrated by the derivation /teye/ → tee → [tie]. This relation is easily modeled with no explicit ordering, by applying every rule applicable at each stage, until no rules are applicable.

/teye/	{ $\gamma$ deletion applicable, diphthongisation is not. Apply $\gamma$ -del.}
tee	{ $\gamma$ deletion not applicable, diphthongisation is. Apply diphthongization}
tie	{ $\gamma$ deletion not applicable, diphthongisation is not. No more rules apply}

The account of feeding exemplified by Kikamba is also simple: /kokéá̃syá/ becomes *kokyáá̃syá* in the first step — only Glide Formation happens to be applicable — and reapplying all rules to that output — only Palatalization would be applicable — giving [kočáá̃syá], and since no other rules are applicable, the derivation is complete. Feeding order poses no problem for this theory.

This approach to rule interaction also handles counter-bleeding relations, for example a relationship between final devoicing and postvocalic spirantization of *g* observed in some Low German dialects. The derivation of /ta:g/ → [ta:x] “day” (cf. plural [ta:γə]) with ordered rules requires spirantization to apply before devoicing. If devoicing were to come first, /ta:g/ → [ta:k] and then spirantization cannot apply (because spirantization does not affect *k* in this dialect). If rules apply simultaneously, as they go in the KSN model, both phonological operations can be performed at once on the final consonant, which gives the correct result.

/ta:g/	{spirantization can apply therefore make the final C become [+cont]}	{devoicing can apply therefore make the final C become [-voice]}
ta:x	{no other rules can apply, the derivation terminates}	

Similarly, Simultaneous application will allow counterbleeding interaction between French nasalization (V → [+nas]/\_\_ [+nas]) and consonant deletion ([+nas] → ∅/ \_\_ {#, C}), where both rules apply in /grand/ → [grãd]: the nasal deletes *and* the vowel nasalizes at the same time.

Other principles of rule application are needed in this theory to guarantee correct results, for example the Proper Inclusion Precedence Principle (very similar to the Elsewhere Condition of Kiparsky 1972, discussed below):<sup>1</sup>

<sup>1</sup> Proper inclusion is a relation defined for string which is analogous to “proper subset”. According to KSN, structural description A *properly includes* structural description B if B can be placed upon A, with some part of A leftover.

For any representation R, which meets the structural descriptions of each of two rules A and B, A takes applicational precedence over B with respect to R if and only if the structural description of A properly includes the structural description of B.

This means that when a specific rule and a general rule can both apply to a string and the change performed by one rule is incompatible with the change performed by the other rule, the specific rule takes precedence over the general rule. The operation of this principle is exemplified by two presumed rules of Latin American Spanish:  $l^y \rightarrow l / \_ \#$  and  $l^y \rightarrow y$ , where  $/akel^y/ \rightarrow [akel]$ , that is, the word-final rule takes precedence over the context-free rule. Given that  $X \rightarrow Y / W \_ Z$  is shorthand for  $WXZ \rightarrow WYZ$ , the structural descriptions of the rules are “ $l^y$ ” and “ $l^y \#$ ”, and the second structural description properly includes the first, therefore the second rule takes precedence over the first (hence only the second rule is allowed to apply). The notion of “incompatibility” is not formally defined, but in this example comes down to the fact that one rule makes  $/l^y/$  become a non-palatal  $l$ , and the other makes be a non- $l$  palatal.

This theory has little provision for handling counterfeeding relationships such as that seen in Lomongo, where  $/o\text{-ina}/$  becomes  $[wina]$  but  $/obina/$  becomes  $[oina]$  and not  $*[wina]$ . Examples were dealt with ad-hoc. KSN mention another dialect of Finnish in which  $/vee/ \rightarrow [vie]$  but  $/teke/ \rightarrow [tee]$ , where derived  $[ee]$  does not undergo diphthongisation. Their solution in this case is to reanalyse “ $ee$ ” as a single long vowel  $/e:/$  in the case where  $/ve:/ \rightarrow [vie]$ , thus they posit a rule of long-vowel diphthongization  $e: \rightarrow ie$ , and treat  $[tee]$  as having two identical vowels. By invoking a distinction between  $e:$  and  $ee$  (for this dialect), they prevent feeding, by not having a rule affecting  $ee$  at all. Ultimately, such moves proved untenable for the full range of counterfeeding phenomena encountered in language. More general solutions addressing the problem of counterfeeding were proposed by Iverson (1973) and Ringen (1976), but these proposals did not receive wide attention.

Another technical problem for the unordered rule theory is the problem of the non-terminating derivation. Given the principle of free reapplication of rule, a stopping condition for derivations is important: it cannot just be “when the last rule has applied”, since no rule has the property of being labeled “last”. The notion “until no rules can apply”, by itself, also does not guarantee that the derivation will end, since a simple word-final stress assignment rule “assign stress to the last vowel of the word” would always be applicable, resulting in the infinite derivation  $/kalaba/ \rightarrow kalabá \rightarrow kalabá \rightarrow kalabá \rightarrow \dots$ . This is resolved via a principle in KSN, fn. 14 which states that “a rule cannot apply to a representation that meets its structural description if the application of that rule would yield an output identical to the input” — i.e. a derivation terminates when no obligatory rules remain that can apply non-vacuously.<sup>2</sup> This cuts down the size of the infinite derivation problem, but does not eliminate it entirely, when a grammar has mutually counterfeeding rules. An example of that type exists in Russian: in that language, all consonants are palatalized before  $i$ , but the alveopalatal sibilants  $\check{s}$ ,  $\check{z}$  are always depalatalized. There is good evidence that the alveopalatals can be palatalized in the derivation — they often derive via a process of palatalization of velars, and they behave as palatal consonants for a rule raising un-

<sup>2</sup> In the context of handling rule iteration in the unordered rule theory, Ringen (1976) proposes a principle that subsumes the ban on vacuous rule application plus a principle that may allow counterfeeding in some instances.

stressed vowels to [i] after palatalized consonants. The problem of nonterminating derivation arises given any sequence /...š*i*.../ (e.g. *karandaš-i* “pens”). Palatalization can non-vacuously apply to this giving ...š<sup>y</sup>*i*..., which then can non-vacuously undergo alveopalatal depalatalization resulting in ...š*i*..., which can non-vacuously undergo palatalization, and so on.

While one of the goals of the Unordered Rule Hypothesis was to constrain phonological theory so that it did not predict unattested phenomena, the mechanisms of the theory predict certain patterns which are prohibited under linear rule ordering. Simultaneous application of rules predicts mappings which are impossible if the connexity requirement is imposed on grammars. An example is the following hypothetical pair of rules. Suppose a language had a rule devoicing stops after short vowels (so /mad/ → [mat] but /ma:d/ does not undergo devoicing, also /maz/ does not undergo devoicing), and a rule lengthening non-low vowels before voiced obstruents (/meda/ → [me:da]). Furthermore, these rules apply simultaneously, so /med/ → [me:t]. If the rules are linearly ordered with devoicing applying first, then /med/ becomes [met] with no vowel lengthening; but if vowel lengthening applies first, the long vowel will block devoicing giving [me:d]. Linear rule ordering only allows the outputs [me:d] or [met]. Thus simultaneous application allows a third output [me:t] which cannot be derived in the standard theory. This indicates an area where the unordered rule theory is *too* powerful, even though it lacks the combinatoric power of rule ordering. However, see Hyman (1993) for discussion of Haya tonology and Chimwi:ni perfective stem formation — discussed below under global rules — for proposed examples of simultaneous rules.

**Iteration.** One aspect of the SPE linear-order characterization of a grammar was challenged early in generative phonology, namely that a rule may not precede itself (irreflexivity). This assumption had very problematic consequences, since it prevents rules from applying to successive strings of segments. A typical problem case of such rule application is vowel harmony, exemplified by the rule of Yawelmani which rounds a vowel after a round vowel if the vowels agree in height, whereby /hubiʂmixhin/ first becomes *hubuʂmixhin*, then *hubuʂmuxhin* and finally [hubuʂmuxhun] “choose (aorist comitative)”, reapplying harmony to its own output, working from left to right through the string (compare /hubiʂtaw/ which becomes [hubuʂtaw] “choose (nondirective gerundial)”, which rounds only the first vowel because the vowel *a* is not of the same height as *u*).

Chomsky & Halle (1968) propose a special formalism to handle this, the star-parenthesis variable notation which in the case of Yawelmani harmony would allow consonants and vowels of the same height to be skipped over. Stating the rule with features (see Chapter 6), Yawelmani harmony would be expressed as follows.

$$\begin{array}{ccc} \text{V} & & \text{V} & & \text{V} \\ [\alpha\text{hi}] \rightarrow [+round] / [+rd, \alpha\text{hi}] C_0 ([\alpha\text{hi}] C_0)^* \_ \end{array}$$

This expands to the following informal infinite sequence:



which satisfies both subrules (a) and (b), only the first rule will apply, giving [sakábat], and not \*[sakábát] as would be predicted by conjunctive application of the rules (it is a formally separate principle, but one not unrelated to the Elsewhere condition and Proper Inclusion Precedence, that the longest expansion is applied first).

The Elsewhere Condition imposes disjunctive application under somewhat different formal circumstances. The central idea of the condition is that disjunction holds between rules A, B, which are so similar that any string that could undergo A can also undergo B — but not vice versa. If the changes performed by the rules are either the same or are mutually incompatible, the “more specific” rule which applies to fewer forms must have precedence over the “more general” or “elsewhere” rule, which applies to the larger set of words. The condition is stated in Kiparsky (1972) as:

Two adjacent rules of the form

$$A \rightarrow B / P \_ \_ Q$$

$$C \rightarrow D / R \_ \_ S$$

are disjunctively ordered if and only if:

- (a) the set of strings that fit PAQ is a subset of the set of strings that fit RCS,  
and  
(b) the structural changes of the two rules are either identical or incompatible.

The point of the latter condition is that, given a rule of intervocalic voicing and a rule palatalizing between high front vowels, we intuitively expect both rules to apply in /iki/ → [igʲi], whereas the set of strings that undergo the rule /k/ → [kʲ] / [i] \_ [i] is in fact a subset of the set of strings that undergoes the rule /p,t,k/ → [b,d,g] / V \_ \_ V. Since the structural descriptions of the rules are not the same, nor are they incompatible, we do not predict palatalization and voicing apply disjunctively — both rules apply.

Part of the argument for the EC is evidence that the SPE prediction about disjunction is incorrect. An example which argues for this is Karok s-palatalization. The rule is:

$$s \rightarrow \check{s} / [-bk, -cons] (C) \_ \_$$

which abbreviates

- a.  $s \rightarrow \check{s} / [-bk, -cons] C \_ \_ \quad \text{and}$   
b.  $s \rightarrow \check{s} / [-bk, -cons] \_ \_$

The non-disjunctivity of the rule is (supposedly) shown by the fact that /ʔissaha/ → [ʔiššaha] “water”; that is, first /ʔissaha/ → ʔisšaha by applying the longer rule, then → [ʔiššaha]. Kipar-

sky notes in this case ‘one subrule is not a “special case” of the other’. This is because some strings which can undergo the longer rule (a) cannot undergo the shorter one (example: /niksup/ → [nikšup] which cannot undergo subrule (b)), and vice versa with /ispuka/ → [ʔišpuk] which cannot undergo subrule (a)). The SPE theory of disjunction incorrectly predicts that no string should undergo both rules, whereas the EC as the determiner of disjunction correctly predicts that these particular subrules will not be applies disjunctively.<sup>4</sup>

There are two counteranalyses of these facts, which avoid the implications of the EC, both related to the status of geminate consonants. One is that, on language internal grounds, the underlying form of this (and all similar words with geminate *ss* undergoing palatalization of both parts of the cluster) is /isaha/ with a single *s*, the geminate being derived by rule (which may then apply after palatalization). The second deals directly with the status of geminates — this is taken up in the readings for the final chapter — that this is really a single, long segment that would better be transcribed as [ʔiš:aha].

Another argument for the EC comes from disjunctivity holding between formally uncollapsible rules. An example is given from Finnish, where /k/ is said to assimilate to the following consonant under certain conditions (across word boundaries, if the following consonant is not *h* and there is no word-initial cluster); otherwise final *k* deletes. Examples which motivate these rules are:

/menek pois/ → [menep pois]	“go away”
/menek alas/ → [mene alas]	“go down”
/menek/ → [mene]	“go”
/huomauttaak professori/ → [huomauttaa professori]	“remarks the professor”

This is explained by the following rules:

- a     k → C<sub>i</sub> / \_\_ #C<sub>i</sub>  
 b     k → Ø / \_\_ #

Clearly, (b) must be ordered after (a): if (b) applied first, final /k/ would always delete, and it would be impossible to then assimilate that /k/ to a following consonant.

The crucial fact motivating disjunction is that /menek kotiin/ → [menek kotiin] “go home”, and the problem is that the [k] derived by applying the assimilation rule should then be deleted, since (b) should ultimately apply. The EC predicts the disjunctive relationship between these rules. The set of strings that satisfy the requirements of (a) would satisfy (b) as well (but not vice versa), and the changes are incompatible since no consonant can be both assimilated and deleted on the surface. The EC thus predicts that any segment that undergoes (a) cannot undergo (b). For cases like /menek pois/ → [menep pois], that result follows from the fact that /k/ be-

<sup>4</sup> The Karok example, and any which are analogous to it, depend on a particular class of rules where a potential rule focus stands in the optional material of a rule. The Crossover Condition of Howard (1972), relevant to the theory of rule iteration and variables, disallows such intervening material. In fact, no persuasive examples of that type have been uncovered so far.

comes [p], and only /k/, not /p/ deletes. What the EC does is distinguish *k*'s which are underlyingly unchanged, versus ones that are the result of applying the assimilation rule. One thing to notice, again, is that the output of assimilation which seems problematic without the EC happens to be a geminate consonant.

Kiparsky discusses an analogous case in Diola Fogy involving place assimilation of nasals and deletions of consonants, and an “extension” of the EC to handle a problem in Sanskrit, involving a coronal assimilation where /t,s/ assimilate to a following coronal (t, ʈ, c), and /s/ becomes [h] “otherwise”. The EC also plays a significant role in formally deriving Non-Derived Environment effects within the framework of Lexical phonology. Interestingly, despite being widely invoked in phonology, the EC does not enjoy a broad degree of empirical support. There is a sense in which some version of the EC states an undeniable truth about rule ordering: if a grammar has two adjacently ordered rules  $X \rightarrow Y /Z\_Q$  and  $X \rightarrow W /Z \_$ , the latter rule cannot apply first. If it did, then every string ZX would have become WX, and there would be no strings of the form ZXQ for the former rule to apply to. And if the former rule applies to nothing, then its presence has no effect on what is in the language, and a child learning the language could never detect that there *is* such a rule in the language.

**Non-derived Environment Effects.** Kiparsky (1976) discusses a recurring problem that arises with unexpectedly non-alternating forms, which he accounts for in terms of a principle termed (in that publication) the Revised Alternation Condition.<sup>5</sup> One illustration of the problem comes from Estonian, where certain consonants are deleted in the genitive singular form of nouns. This creates vowel clusters that undergo a vowel lowering rule, where a high vowel lowers before or after another vowel. Thus nominative singular *tuba* ‘room’, *viga* ‘fault’ and *lugu* ‘story’ become *toa*, *vea* and *loo* by consonant deletion and vowel lowering. The problem is the invariant noun *luu*, *luu* ‘bone’ (n.s, g.s), which fails to undergo vowel lowering. The generalization which explains the failure is that lowering does not apply when its structural description is satisfied in the underlying form. In the derivation of /lugu/ → [loo], the rule of consonant deletion must first apply, in order to create the vowel cluster that undergoes lowering. But that cluster is already present underlyingly in /luu/ ‘bone’.

A similar example comes from Finnish, which has a rule of assibilation where  $t \rightarrow s / \_ i$ . This rule applies in [halus-i] “wanted” from /haluti/, cf. [halut-a] “want”. It also applies in [vesi] “water (n.s.)”, from /vete/ (cf. [vete-nä] “water (essive)”). The derivation of [vesi] also involves the final vowel raising rule (discussed in Chapter 4) where word-final /e/ becomes [i]: this /vete/ → *veti* → [vesi]. The problematic forms are *koti* “house (n.s)”, cf. *kodi-n* “house (acc.s)” and *tili* “account (n.s)”. Again, the sequence *ti* is always present in the underlying form of /koti/, /tili/. Where the rule applies, it applies if the conditioning environment is created across morpheme boundaries, or by the application of a phonological rule. If the sequence is found morpheme-internally in the underlying form, the rule does not apply. A third example of such rule blockage is found in Swedish, which is said to have a rule  $k \rightarrow \zeta$  (and  $g \rightarrow \gamma$ ) before front vowels, accounting

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<sup>5</sup> One of the motivating principles behind this proposal is the desire to limit where global rules are possible — see the discussion of global rules below. The important point for RAC is that certain rules need to be able to inspect the underlying form.

for the alternations [kamp] “a fight” ~ [çämpa] “to fight”. There are underived forms where velar fronting fails — [kiruna] (place name), [fakir] “Sufi mendicant”, [kitt] “putty”, [gitta] (proper name) — all being instances of /ki, gi/ standing inside a morpheme, where neither the vowel nor the consonant are derived by rule.

Kiparsky proposes the *Revised Alternation Condition* to govern this: “Non-automatic neutralization processes only apply to derived forms”. This raises the question of what a “derived form” is:

“The following thus appears to be the general case: a rule may be blocked morpheme-internally if the environment is met in the underlying representation. I will refer to an input which is created by combining morphemes through derivation or inflection, as in (a), or by applying a phonological rule, as in (b), as a DERIVED input”. [p. 163]

Another question that comes up is in connection with RAC is, what is an “automatic” rule? Given rule  $P$  of the form  $A \rightarrow B /XC\_DY$ ,  $P$  is nonautomatic if there are strings of the form CAD in the immediate output of  $P$  — it ‘has exceptions’ — and otherwise  $P$  is automatic. As we know, a “neutralizing” rule is one where there are strings of the form CBD in the immediate input of  $P$  and  $P$  creates CBD; otherwise  $P$  is non-neutralizing.

These conditions are imposed on RAC for a reason. Why “non-automatic neutralization”? The condition “neutralization” is imposed because, as we know, allophonic rules apply everywhere the context is found,<sup>6</sup> for example: /əpláy/ → [əp<sup>h</sup>láy] and /kip/ → [k<sup>y</sup>ip]. These are underived forms, and if the RAC were to hold of *all* rules, it would predict that allophonic rules would not apply in underived environments, but we know that allophonic rules apply everywhere. Why “non-automatic”? It turns out that there are some neutralization rules which apply everywhere, specifically cases of “absolute neutralization” where phonetically non-occurring segments always neutralize (e.g. /u:/ → [o:], merging with /o:/ everywhere in Yawelmani — see chapter 9).

Some of the examples selected to illustrate RAC also point to a problem in interpreting whether the conditions that it calls for are encountered, as seen in the problem of Sanskrit *ku-suma* “flower”. Sanskrit has a rule, known as the “ruki” rule, which changes /s/ to [ʃ] after the segments /r,u,k,i/, where we would expect that rule to turn /kusuma/ into \*[kuʃuma]. How can RAC explain failure of the rule? First we must determine if this is a derived form, hence initially in the purview of RAC. The structural description of the ruki-rule is satisfied morpheme-internally in the underlying form — the morphological structure is /kusum+a/, and no phonological rules apply to this — so this is an underived form. Is the ruki-rule a non-automatic neutralization? We have to consider this question in two parts. First, is this a neutralization? The retroflex sibilant [ʃ] is not a highly robust phoneme of the language, and in fact most instances of it derive from applying the ruki-rule or another rule that affects /ç/ before /t/. There are cases of underlying [ʃ] (*ṣat* “six”) which shows that /ʃ/ is an independent phoneme, but Kiparsky specifically means “in the context stated in the rule”, i.e. after /r,u,k,i/. So the question is whether there are any cases of underlying /uʃ/. Kiparsky makes a good empirical case that there are, viz. /piʃ/

<sup>6</sup> Gedankenshausaufgabe: why is that a tautology?

‘crush’, based on facts of infixation. In the present tense of this root (and others in its morphological class), there is an infix *-na-* before the root-final consonant, cf. [pi-na-ʃ-ti] “crushes”. This can be explained by positing the underlying form /piʃ/, rather than /pis/, whereas if we assume /pis/, then it is hard to explain the presence of [ʃ] when the conditioning environment is not actually present. Another argument for underlying /ʃ/ after /u/ draws on a righthand contextual restriction on the ruki-rule. That rule does not apply before *r*, as shown by [usras] “dawn”, from /was-ras/. Note then that there is no blockage in [a-juʃ-ran] “enjoyed”: this can be explained by assuming that the underlying root is /juʃ/ and not /jus/; the retroflex sibilant is *underlyingly* /ʃ/, so there is no rule application to block.

The second part of the RAC is that the rule must be a non-automatic rule (since, recall, absolute neutralization rules *do* apply in underived environments). There are exceptions to the ruki-rule, i.e. cases of /...us.../ in the immediate output of the rule, namely *kusuma* itself. In fact, the only exceptions to the ruki-rule (actual exceptions, as opposed to complications posed by the restriction that *r* may not immediately follow) are non-derived environment forms such as *ku-suma*. This means that in order to know whether the ruki-rule is blocked (whether the RAC hold) and thus creates exceptions, we must know whether the rule is automatic, i.e. whether the rule will have applied in *ku{s/s}uma*. In short, we encounter a circularity problem in determining whether RAC is relevant. Later accounts of the RAC especially in the framework of Lexical Phonology have avoided this problem: see Kiparsky (1993) for an interpretation of the Strict Cycle Condition and Non-Derived Environment Blocking in terms of underspecification. Another tack is taken especially in the analysis of NDEB effects in Lubowicz (2002), whose OT analysis separates the phonologically derived and the morphologically derived, and essentially treats NDEB as an unpredictable property of a grammar. One further solution to the problem of non-derived blocking is to assume that non-alternating words like *kusuma* are lexical exceptions to the rule in question, and not try to explain the non-application of the rule.

**Global conditions.** The standard model of ordering states that when a rule applies to a form, the only thing that the rule can consult is the form itself. This restriction has been relaxed in a number of ways. The Elsewhere Condition requires a computation involving some previous rule, the more specific rule, and also requires knowledge of whether a given string has actually undergone that rule (in order to know if a string is “the output of” the earlier rule). The Revised Alternation Condition requires consultation of the underlying form and various steps of the derivation to see if a form is a “derived form”. Reference has also been made to the concept of Structure Preservation in the book, invoking non-local readjustments to the output of a rule in order to conform to certain “structural canons” in the language.

A further type of non-Markovian rule application (where rules inspect something other than the rule-input itself) has been proposed in the form of “global rules”. These are rules which directly refer back to properties of underlying forms, subsequent to applying a rule which destroys the relevant information. An example of such a proposed rule is the rule shortening the perfective suffix vowel in Chimwi:ni (Kisseberth & Abasheikh 1975). The perfective suffix in this language is underlyingly /-i:ɬe/,<sup>7</sup> which surfaces as such (or with a vowel harmonic variant)

<sup>7</sup> The consonant *ɬ* is described in a manner suggesting that it is a surface flap, [ɺ].

in e.g. *pamb-i:ɫe* ‘he decorated’, *xat-i:ɫe* ‘he went without’, *set-e:ɫe* ‘he stamped on’, *tiy-i:ɫe* ‘he feared’, or as the variant *-i:ze* as in *raši:ze* when the preceding consonant is a sibilant. The perfective also conditions certain consonant changes where the voiceless stops /p, t, tʰ/ become [s], /k/ becomes [š] and /ʈ/ becomes [z], thus *ku-lipa* ‘to pay’ ~ *lis-iɫe* ‘he paid’; *ku-laṭa* ‘to let go’ ~ *las-iɫe* ‘he let go’; *x-ši:ka* ‘to hold’ ~ *ši:šile* ‘he held’; *x-kula* ‘to grow’ ~ *kuzile* ‘he grew’. The vowel of the perfective suffix is also shortened, under the condition that the preceding consonant is mutated. Stating such a condition on a rule of vowel shortening is impossible under the standard theory of rules, since there is no way to distinguish consonants which become mutated, as in *lis-iɫe* from /ɫip-i:ɫe/, from phonetically identical consonants which are underlying sibilants, as in *kos-e:ze* ‘he made a mistake’ /kos-i:ɫe/ (cf. *x-kosa* ‘to make a mistake’). Furthermore, it is clear that the rule cannot simply refer directly to the nature of the underlying consonant, since there are lexical exceptions to consonant mutation, such as *set-e:ɫe* ‘he stamped on’, and just in case an otherwise mutable consonant fails to mutate, the vowel of the perfective remains long. The proposal by Kisseberth & Abasheikh is that the vowel shortening rule be given the ability to look backwards in a derivation to see if the preceding consonant has undergone mutation. However, they also note that a transformational-format rule which combines mutation and shortening avoids the need for global rules; Hyman (1993) proposes a number of other alternatives such as an autosegmental feature-sharing account, and a morphological stem-variant analysis which avoid global references to underlying forms.

A relatively compelling example of global reference is argued for in Miller (1975). It is shown that in Greenlandic, *t* becomes *s* intervocalically when it is after *i*, thus /iga-tit/ → *igatit* ‘your sg. cooking pots’ but /iki-tit/ → *ikisit* ‘your sg. wounds’. The intervocalic requirement is motivated by forms such as 3 sg. opt. “come” *tikit-li*, cf. passive participle *tikis-aq*. Assibilation does not apply after an epenthetic *i*, cf. *siut* ‘ears’, /siut-tit/ → *siut-itit* ‘your sg. ears’. An obvious move is to order epenthesis after assibilation, but this is wrong because such an ordering would falsely predict that vowel epenthesis does not contribute to determining whether /t/ is intervocalic — in fact epenthesis must precede assibilation, cf. *sillit* ‘whetstone’, /sillit-tit/ → *sillisitit* ‘your sg. whetstone’. The conclusion to be drawn from these examples is that assibilation only applies after a vowel which is underlyingly /i/, a determination that has to be made by globally looking at the underlying form.

Other proposed global rules of phonology are proposed in Kisseberth (1973a) for Klamath and McCawley (1973) for Bangubangu. Problems regarding the apparent need to distinguish underlying L tone from L derived by deletion of H in Bantu languages have been discussed in terms of globality (though with the goal of avoiding explicitly global rules) by Hyman (1981) for Luganda, Hyman & Byarushengo (1984) for Haya, and Hyman & Valinande (1985) for Kinande. Kisseberth (1973b) advances the idea that explicit rule ordering might be eliminated by imposing global conditions on phonological rules. This would allow the counterfeeding of Lomongo *b*-deletion vs. syllable fusion to be expressed by imposing a restriction on syllable fusion that only underlyingly adjacent vowels undergo fusion.

**The Cycle.** Another modification to the concept of strict linear ordering of phonological rules, one which predates the standard statement of generative phonology in SPE, is the cycle — we have not seen this mode of rule application so far. Cyclic application results in the situation

where two rules apply in the order  $A > B$ , but in the course of a derivation one finds rule applications of the type  $A$ , then  $B$ , then  $A$ ; or,  $A$  followed by an application of  $A$ , but in a manner that cannot be subsumed under the concept of rule iteration. By themselves, such examples would be serious ordering paradoxes. The order  $A > B > A$  violates the asymmetry condition on ordering. Such violations are allowed in the SPE theory only under the conditions of cyclicity. When a rule applies cyclically, it first applies scanning only a substring of the word — generally a morphologically defined unit such as a root or stem — and then it reapplies to a larger string that includes the first substring and additional morphemes.

An example is the interaction between  $u$ -umlaut and syncope in Icelandic. The first rule changes /a/ to [ö] before  $u$ , so /bagg+ul/ becomes [böggul] “package (acc. sg)”. The underlying quality of the initial vowel is motivated by *bagg-i* “pack”. Syncope deletes a non-initial vowel in an open syllable, whereby /hamar+i/ becomes [hamri] “hammer (dat. sg)”. The fact that /katil+um/ becomes [kötlum] “kettle (dat. pl)” demonstrates that Syncope precedes  $u$ -umlaut — Syncope eliminates the vowel  $i$  that would block  $u$ -umlaut. However, underlying /bagg+ul+i/ becomes [böggli] “package (dat. sg)”, which can only be explained by applying  $u$ -umlaut first, then Syncope. This yields the paradox that Syncope precedes  $u$ -umlaut but  $u$ -umlaut precedes Syncope.

Applying these rules cyclically removes the paradox, by exploiting the fact that the underlying forms /bagg-ul-i/ and /katil-um/ differ in morphological constituencies — [[bagg-ul]-i] vs. [katil-um], the former involving a monosyllabic root plus a derivational affix, the latter having a disyllabic root. With cyclic rule application, Syncope precedes  $u$ -umlaut. These rules apply to the smallest substring which has no internal brackets, thus, they apply to *bagg-ul* and *katil-um* respectively. Under the ordering Syncope  $>$   $u$ -umlaut, the form *kathum* is first derived. Both words undergo  $u$ -umlaut, giving *böggul* and *kötlum* at the end of the first cycle of rule application. Then the internal brackets on [[böggul]-i] are removed, resulting in *böggul-i*, which is again subjected to the rules of the phonology; Syncope applies, giving [böggli]. Strict linear ordering holds for each part of a derivation corresponding to the material within a cyclic domain. See the associated document “Cyclicity” for further examples of cyclic rule application.

The earliest uses of the cycle in phonology were for stress assignment, both phrasal stress and word-level stress — see Chomsky & Halle (1968) — and it was often assumed at that point that only stress rules were cyclic. Further arguments for the cycle are found in Kisseberth (1971), Kaye & Piggott (1973), Brame (1974), Kean (1974), Mascaro (1976), and Rubach (1984) *inter alii*. Cole (1995) overviews a number of theoretical issues relevant to the phonological cycle. Having rules that apply cyclically raises two fundamental questions: what defines the domain of a cycle, and which rules are cyclic? The model of Lexical Phonology (Kiparsky 1982 and others) provides a mechanism for automatically deriving the cycle, via that theory’s interaction between phonology and morphology where a form is resubmitted to the phonology. It also offers a partial answer to the question of which rules are cyclic: only lexical rules may be cyclic (however, not all lexical rules are cyclic, see for example Rubach 1990).

**Further theories of rule interaction.** Other proposals for rule interaction include the theory of Local Ordering (Anderson 1974); Two-level phonology (Koskeniemi 1983, Karttunen 1993), and especially Harmonic Phonology (Goldsmith 1993) which includes both a reapplicative compo-

ment within a level that allows an account of feeding relations, and a single-step mapping between levels, which enables counter-feeding relations to be captured. This approach addresses many of the empirical flaws of the original Unordered Rule Hypothesis, which especially ran into problems with counter-feeding.

Optimality Theory (discussed separately) approaches the issue of rule ordering differently: because OT has no rules, there can be no rule ordering. OT more closely resembles the Direct Mapping Hypothesis of Kenstowicz & Kisseberth 1978 (also Koskeniemi's two-level phonology), since there are no intermediate steps between the underlying and surface forms. In OT, a surface form is selected directly, by reference to the relationship between the underlying form and the surface form, with respect to a set of constraints that are evaluated in a particular order that needs to be specified for the language. OT still requires a combinatoric device with the permutational possibilities found with rule ordering, in the form of constraint ranking — a grammar in OT is seen as a set of ranked (ordered) constraints, so we face the question of possible permutations, in this case, permutations of the set of constraints. Derivationally intermediate forms are not part of a standard OT account. Kiparsky (2000) proposes a hybrid model of Lexical Phonology and Optimality theory, along lines conjectured by McCarthy & Prince (1993) for Axininca Campa and other places in the OT literature, where a phonology has ordered levels, but the content of each level is a single input-to-output mapping as typically assumed for OT (and Harmonic Phonology). In addition, recent work in OT in the area of Harmonic Serialism has replaced the single-step derivation from underlying forms to surface forms with a repeated processing of a form, improving the input one step at a time.

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