Phonology, part 2: the logic of ordered rules

1 What rule ordering means

We’ve seen that in certain situations, rule ordering allows us to capture important generalizations about the way in which mental representations are mapped to actual pronunciations. The discussion of the English plural rule in the previous handout is really all about the naturalness of the alternations $[z]$ $\sim$ $[s]$ $\sim$ $[\@ z]$—in particular, the elimination of $[\@ z]$’s status as a special case, allowing us to derive it as a byproduct of the Schwa Insertion rule. And the latter rule my in turn be understood as a natural concession to the hearer’s perceptual requirements in the face of the excessive noisiness that a series of fricatives introduces into the stream of speech sounds. But this view of the plural may be somewhat misleading, conveying as it does the idea that rule ordering is a way to arrange for something to bring about a phonetically (or phonologically) desirable result—e.g., the rule of Schwa Insertion applies first ‘in order to’ allow a kind of perceptual buffer between the strident final stem obstruant on the one hand and the strident plural marker on the other. and then the Devoicing rule applies, ‘in order to’ allow the plural marker to maintain its underlying voicing in the environment of the newly introduced, voiced $\@$. This is a very comfortable way of thinking about rules and rule ordering, but one which isn’t really useful.

The right way to think about rule order is one I mentioned in class last week: the order $A > B > C$ amongst three rules $A$, $B$, $C$ really reflects the fact that rule $A$ takes precedence over rule $B$ and $B$ in turn takes precedence over $C$, in the same way that special cases take precedence over the default in all kinds of situations, without any sense of an actual ‘before’ and ‘after’. The Oneida phonology problem we’ve looked at is a nice illustration of the kind of sense made by taking this perspective.

The rule system I suggested as the simplest solution to the Oneida problem can be stated as follows:

\[
/\text{z}/ \rightarrow \@ y > \z \rightarrow /\text{y}/ > \z \rightarrow /\text{V}/
\]

Consider how these these three rules will apply, in the order given, to the following four lexical items from Oneida. There is exactly one change in each line in the following table, because the rule specified at the beginning of each line gets to apply to exactly one of the words in the set:

<table>
<thead>
<tr>
<th>Phonemic</th>
<th>/lakza/</th>
<th>/tʰizkɑːtɛ/</th>
<th>/wežakό/</th>
<th>/tɛʰšyaʔk/</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\z$ → $@ y$</td>
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<td>tʰizkɑːtɛ</td>
<td>wežakό</td>
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</tr>
</tbody>
</table>

It’s very important to see how these rules operate in practice, under the restrictions imposed by ordering. The first rule applies, taking $\z$ as its input in the second line, yielding $\@$ in the rightmost form. Look at what happens after the first rule, palatalization, has applied. It only affects one of the forms, because the
environment of the rule specifically targets instances of \( z \) which immediately precede the palatal semivowel \( y \), and only one of the words in the set contains \( z \) in that environment. The next rule targets instances of \( z \) which occur before consonants. And note carefully that I say, ‘before consonant’, rather than, ‘before all consonants except for \( y \)’. The reason for the simpler statement is that I don’t have to go out of my way to exclude cases of \( z \) immediately preceding \( y \)—because, at the point when the rule applies, there are no such cases! We have an instance of \( \delta \) immediately before \( y \), but so what? The rule says nothing about, and has no interest in, \( \delta \); it specifically tells you what happens to \( z \), and \( z \) alone, right before \( y \). The whole point of ordering the rules the way I’ve done is that, by the time you get to the second rule, there are no cases of \( z \) before \( y \) which would be affected by the operation of the second rule—anything which was a \( z \) before \( y \) previously has been changed into \( \delta \), and so is forever beyond the reach of any other rule affecting \( z \).

Similarly, at the point when the third rule applies, there will be cases in post-vowel position of sound-representations which were formerly \( z \). But those cases will be completely unaffected by the third rule. Why? Because the third rule tells you what happens to \( z \) after a vowel, but \( s \) in the second column of data is no longer \( z \)! So the third rule will have nothing to say about such cases, where the environment is what the rule is targeting (the position after vowels), but the things in that environment are no longer the kind of entity (\( z \)) that the rule applies to.

And after the third rule has run its course, there will be no further rules applying to \( z \). Which means, of course, that the mental version of this sound will be unchanged from in all of the initial and post-vowel environments at the point when the rule system ‘delivers’ the mental representation to the vocal tract for pronunciation. We thus wind up with the phonetic representations of these words given in the last line, depicting, in the IPA-ish transcription system I’ve introduced, exactly how each word should be pronounced.

What is happening in the Oneida case is that the first rule ‘trumps’ the second and third in terms of its applicability—if you see a \( z \) followed by \( y \), you don’t pay attention to anything else. One you’ve followed the ‘instructions’ dictated by the first rule, you shift your attention to the second rule and look for any cases of \( z \) followed by a consonant—any consonant at all. As I’ve already explained, you don’t have to say anything about ‘... except for \( y \)’, because, at this point, there will be no cases of \( z \) preceding \( y \). And the second rule trumps the third, so that all that needs to be mentioned is the presence of a following consonant. That’s the real point of ordering—it highlights the relatively simplicity of the actual processes which apply, by removing what can be interpreted as extraneous material from the environment in the rule. The ‘cost’ of this simplification is the notion of ordering itself, but all ordering is is the idea that certain rules take precedence over others, as opposed to being organized on a ‘free choice’ basis where you don’t have to pay attention to any kind of ranking amongst the rules.

Another nice example of the use of ordering to make sense out of what at first seems difficult to understand comes from another Iroquoian language, Mohawk:
<table>
<thead>
<tr>
<th>Phonemic</th>
<th>Phonetic</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>hra+nyahes+s</td>
<td>ranahéczas</td>
<td>‘he trusts her’</td>
</tr>
<tr>
<td>hra+ket+as</td>
<td>ragédas</td>
<td>‘he scrapes’</td>
</tr>
<tr>
<td>wa?+hra+ket+?</td>
<td>walahágede?</td>
<td>‘he scraped’</td>
</tr>
<tr>
<td>o+wis+?</td>
<td>ótwize?</td>
<td>‘ice, glass’</td>
</tr>
<tr>
<td>wake+nuhwe?+u+ne?</td>
<td>wagenuhwe?úme?</td>
<td>‘I had liked it’</td>
</tr>
<tr>
<td>4+k+hate+?</td>
<td>4khá:de?</td>
<td>‘I shall go ahead’</td>
</tr>
<tr>
<td>ya+k+ni+râm+ot+?</td>
<td>yageniró:node?</td>
<td>‘we two (excl.) are singing’</td>
</tr>
<tr>
<td>ya+k+ni+eyara?+s</td>
<td>yagenehyára?s</td>
<td>‘we two(excl.) remember’</td>
</tr>
<tr>
<td>ya+k+wa+râm+ot+?</td>
<td>yagwaró:node?</td>
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<td>yagwehyára?s</td>
<td>‘we two(excl.) remember’</td>
</tr>
<tr>
<td>hra+yâtho+?</td>
<td>rayâthos</td>
<td>‘he plants’</td>
</tr>
<tr>
<td>hra+eyara?+s</td>
<td>rehyára?s</td>
<td>‘he remembers’</td>
</tr>
<tr>
<td>ye+k+hrek+?</td>
<td>yékreks</td>
<td>‘I push it’</td>
</tr>
<tr>
<td>ye+4k+hrek+?</td>
<td>yókrege?</td>
<td>‘I will push it’</td>
</tr>
</tbody>
</table>

Clearly, there’s a lot going on here. But you only need to pay attention to one phenomenon, to start with: which vowel gets to bear stress? Begin with that question, and see where it takes you. My (strongly urged!) suggestion: try to work out that answer for yourself, based on the data, and see what you come up with. The training in problem solving that such problems offer will be very useful in confronting exam and assignment questions. The problem makes it easy for you: you are given the underlying, mental representation up front—the phonemic forms are, after all, just that. And you know what the output is, from the ‘Phonetic column’. So all you need to do is discover the optimal set of rules (i.e., the simplest set) that takes you from the phonemic input to the phonetic output in each case.

Here’s the right line of analysis: start with the simplest statement about where stress shows up that you can think of, and don’t worry about the phonemic representation. In the first two examples, stress shows up on the penultimate syllable—the syllable immediately preceding the final syllable of the word. So we start with that as our candidate rule: stress the next-to-last syllable. But when we get to the third example, things don’t work that way—there is not one, but two vowels after the stressed vowel. We’d expect the phonetic form to be *[wahagéde?]* (taking into account that vowels in this position lengthen when they receive stress). And in the fourth problem, the result is the same. But in the fifth and sixth problem, the penultimate stress rule seems to be operative again. The problem, then, is that there seems to be a difference between the cases where the penultimate vowel takes stress, on the one hand, and those where stress falls on the pre-penultimate vowel. What is it?

At this point, you need to look at the phonemic representations to see if there’s anything that gives you a clue about what distinguishes the two situations. There are two things you should be able to do, given the above data and information about phonemic forms:

- identify what properties of the phonemic form correlate with the appearance of stress on the penultimate vowel in the phonetic form, and
- work out a simple story about how this correlation comes about which works in all cases.

The second of these requirements is a good deal more demanding than the first, because it involves several extra reasoning steps. But you should be able to work out the story (at least roughly) along the following lines:
i. Careful inspection of the data should have revealed to you that stress falls on the phonetic penultimate syllable always, and only, when that vowel is also the penultimate vowel in the phonemic representation. In the first two examples, the phonetic [\textipa{e}] corresponds to the next-to-last vowel in the phonemic representation. In the next two, the penultimate phonetic vowel is not the next-to-last vowel in the phonemic representation. Rather, it’s /a/ and /o/ respectively which are... and they are the vowels which bear phonetic stress. The penultimate phonetic vowels in these examples are actually the last vowel in the phonemic representation. This pattern holds across all of the data, without exception.

ii. The pattern just noted in (i) means, of course, that an extra vowel has to come from somewhere—after all, if the phonemic last vowel shows up as the phonetic next-to-last vowel, it means that the phonetic last vowel had to come in somewhere on the way to the phonetic form of the word. In phonological terms, what has happened in these cases is that a vowel has been inserted, presumably on the basis of a phonological rule.

iii. We now have two rules to think about: the rule introducing stress, and the rule introducing vowels. Could the distribution of stress be a matter of the interaction between these two rules? It’s a pretty good bet that it is. A penultimate syllable stress rule counts one back from the vowel at the end of the word—which means that if a vowel is in final position at the point when the rule applies, it won’t receive stress; instead, the vowel in front of it will. So if the phonemic final vowels are still in final position at the point when the stress rule applies, it follows that they won’t receive any stress at all. If we assume that the stress rule applies to the phonemic form of words, then we will automatically get stress on the vowel in the syllable preceding the last-syllable vowel.

iv. But since the last-syllable phonemic vowel is the penultimate vowel of the phonetic form of the word, we have to ensure that the insertion rule for the vowel that shows up in the phonetic pronunciation in final position in these cases only applies after the stress rule has applied. In other words, the Stress Rule for Mowhawk must apply before the Insertion Rule. We haven’t actually formulated either of these rules yet, but the logic of the situation pretty much forces this ordering on us.

From this point on, the problem gets much easier. All you have to do is formulate a Stress Rule and an Insertion Rule which separately account for the relevant facts; now that you know how the rule system operates, you can focus simply on getting the vowel inserted in the right places, and stating the stress rule so that stress falls on the penultimate vowel. These statements demand some care, however; they should only have the required effect in the particular places where the effect arises.

Start with the Stress Rule—how do we convey that the vowel of the next-to-last syllable receives stress? In any word, the vowel of the last syllable will be separated from word-final position, marked by \textunderscore\text#, by zero or more consonants, so that the ‘ultimate’ vowel occurs will be \textipa{VC_n\#}, where the notation \textipa{C_n} stands for the following sequences of consonants: ε (the empty sequence, i.e., no consonants), C, CC, ... And the vowel of the preceding syllable will be separated from the final vowel in the same way, by zero or more consonants. That is, the ‘position’ occupied by the penultimate vowel can be written \textipa{C_n\#}. So the Stress Rule can be written

\textbf{Stress Rule:} \textipa{V \rightarrow \text{[stress +]} / C_n\text{VC}_n\#}

The Insertion Rule is slightly trickier, because, as you may have noticed, the conditions which seem to trigger in certain cases don’t always do so. To start with, let’s just look at the data in the first half of the problem, where we see evidence of the following pattern:

\begin{center}
\begin{tabular}{ll}
/t/ & /s/ \\
t/ & s/ \\
\end{tabular}
\end{center}

Other phonological rules must apply to give us the final phonetic forms [de?] and [ze?] which appear in the third and sixth forms, and fourth form, respectively. But it seems clear that when we get certain consonants
in sequence, the Insertion Rule is triggered. The phonological units t and s are both obstruants, so one hypothesis we might propose is that when we have a series of obstruant + ?, we get [ε] inserted.

The data in the second half of the problem require a revision of this statement. Looking at the first few of the longer forms, we see that we also have

\[ /kn/ \]

ken

This isn’t the most beautiful pattern in the world, as things stand, but we can make it a bit more natural if we bear in mind that n, like ?, is actually a stop—there is a complete closure in the oral part of the vocal tract, which is what the term ‘stop’ actually designates. And k is a straightforward obstruant. So we can state the rule very strongly as:

**e-Insertion:** \( \emptyset \rightarrow \varepsilon/obstruant\_stop \)

It’s a good idea to frame the rule in this way, the strongest form that the facts are compatible with. For one thing, if we’re wrong, then new data will show this very quickly and we’ll have to ratchet down the strength of the rule to fit the new data. But a very weak statement of the rule won’t have to be revised, even if it turns out that a stronger statement is possible.

Summarizing, we have the following two ordered rules

**Stress Rule:** \( V \rightarrow [stresses +]/\_C_nVC_n# \geq \)

**e-Insertion:** \( \emptyset \rightarrow e/obstruant\_stop \)

Our account is still incomplete, because we have not said anything about the change in vowel length which appears to be associated with stress placement. You’ll notice that the stressed vowels in all but three of the Mohawk words are lengthened. It would be nice if we could add a rule to the system that assigned length to stressed vowels, but what about the three cases where we don’t find this added length? Can you see what the determining factor is?

The solution turns out to be straightforward: in all three cases, the unlengthened stressed vowels turn out to precede a sequence of consonants. All of the other stressed vowels in the problem set precede a single consonant. Very often, a sequence VCCV corresponds to a division into syllables \([σ VC][σ CV]\). So it may well be that vowels stay short, even under stress, when they occur within a closed syllable, i.e., a syllable which ends with one or more consonants. We’re in position to write the length rule now—almost! But we’re not quite there. There is something going on with vowels in the second half of the problem which we can provide an explicit rule for, which may be tied to some extent to the issue of stress (and therefore length). We need to see whether or not it is, before we proceed further.

Consider the very last word, and ask yourself just what is going on between the phonemic and phonetic forms. There seems to be a process which is the opposite of insertion at work here: the phonemic form in this example contains three vowels, and the phonetic form, after the application of the insertion rule, contains three vowels. So that must mean that one of the original vowels disappeared. Apparently, /eΔ/ → o. And this output of the rule bears stress. Where would it have gotten stress from?

Before we answer this question, let’s see where else we have this kind of effect. We find the following:

\[
\begin{array}{ccc}
/e/ & /a/ & /e/ \\
\varepsilon & e & \circ
\end{array}
\]

It looks as if the first of two vowels is eliminated when they occur in a sequence. But something a bit more complicated appears to be involved in the third case: the result of the combination not only eliminates the first vowel, but (in the transcription system of the source for this data) displaces the second vowel to the
back. We don’t have enough data to decide exactly how the rule should be stated, but what we need to wind up with is a process where in a sequence $V[\text{front}]V$, the second vowel stays front if it’s front, and becomes the corresponding back vowel if it’s non-front; then the first vowel disappears. We won’t worry about the first part of this process, but the deletion rule itself can be simply stated as follows:

**Deletion rule:** $V \rightarrow \emptyset / _{\text{back}}V$

This rule does not need to be ordered with respect to either the stress (and hence the lengthening) or vowel insertion rules (to test your own understanding of the preceding discussion, try to formulate for yourself carefully just why this statement turns out to be true).

We can now proceed with the lengthening rule, which occurs after stress is assigned, but does not interact with the insertion rule (since the lengthening rule only involves the vowel which receives stress). As we already concluded, the lengthening can be stated as a lengthening of stressed vowels just in case these occur in open syllables. The rule will then look formally very much like the following:

**Length Rule**

$V[\text{stress}] \rightarrow [\text{length}] / _{\text{CVX}}$

where X is a cover symbol for any phonological sequence. The point is, it doesn’t matter what follows the vowel in the next syllable, as long as there’s only one consonant separating the stressed vowel from the following vowel.

We can summarize our results so far as the following rule system:

(i) **Stress Rule:** $V \rightarrow [\text{stress}] / _{\text{C}}V, \# >$

**e-Insertion:** $\emptyset \rightarrow e / \text{obstruant}_n \text{stop},$  

**Length Rule:** $V[\text{stress}] \rightarrow [\text{length}] / _{\text{CVX}}$

(ii) **Deletion rule:** $V \rightarrow \emptyset / _{\text{back}}V$

This notation is to be understood as follows: the rules in (i) form a set under a partial ordering, with the Stress Rule applying before both e-Insertion and the Length Rule, where the latter two are unordered with respect to each other. There is a second set, consisting only of the Deletion Rule, which has no ordering relation to the first set.

These four rules very economically provide an empirically satisfactory mapping from the underlying, psychologically real (=phonemic) representations to the phonetic forms that can be pronounced, recorded and measured in various ways. Without ordering, it would be monstrously cumbersome to provide an account of Mohawk phonology which covers the same ground.