THE ARPA-SUR PHONOLOGICAL RULES:

SUMMARY AND INDEX

by

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ABSTRACT

The phonological rules distributed by the various SUR groups are classified into a number of broad categories, each of which is briefly described. An index listing each rule and its category is included.

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PREFACE

At the ARPA-SUR Phonological Rules Workshop, held in Santa Barbara on January 7 and 8, 1974, it was decided that:

1. All SUR sites having collections of phenological rules would distribute these rules in a standard format, and
2. a committee would review and evaluate these collections of rules.

Although this note is a direct result of the second point above, it stops short of a complete evaluation of the rules. Instead, it classifies, annotates, and cross-indexes the rules in a way which will hopefully provide a basis for comparison and discussion of the more than 200 rules.

I would like to acknowledge the assistance of the members of the ARPA-SUR Pheonological Rules Evaluation Committee. In particular, the contributions of Linda Shockey, of Carnegie-Mellon University, have been especially helpful.

I am solely responsible for omissions or misinterpretations of the rules.

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INTRODUCTION

Natural continuous speech exhibits a great deal of phonological variation. Although this variation is partly random, much of it is accounted for in systematic ways by phonological environment, speech rate and style, dialectal influences, and other similar factors.

Research in the automatic (machine) understanding of continuous speech has given a new impetus to the description and systematization of this phonological variation. Phonological rules represent an attempt to characterize this variation in one of several semi-formal notations.

Several of the ARPA-SUR groups have distributed collections of phonological rules. They almost uniformly ignore the problem of derivational or morphophonemic variation (such as the difference between the pronunciation of /a/ in "sane" versus "sanity", or /g/ in "gnostic" versus "agnostic"), and focus instead on the variation between actual and "standard" pronunciations. They deal principally, though not exclusively, with variation at the phonemic level due to phonological environment.

Purpose:

Since the rule collections distributed by the seven SUR groups contain a total of some 242 rules, with a fair amount of overlap, even comparing the rules with one another becomes a time-consuming and tedious job. The primary goal of this note is to facilitate this task of comparison.

It should be emphasized that no attempt is made to present a definitive set of rules, or, except in a most cursory way, to evaluate the correctness or usefulness of specific rules.

Organization:

The major portion of this note is devoted to a classification of the rules into roughly 30 broad categories. The starting point for this classification was the paper by Oshika, et al. (1). Basically, each group contains rules which act similarly on a particular phoneme, class of phonemes, or with regard to a particular feature. Niceties of classification have been ignored in order to obtain a reasonable number of rules in each group.

These groups are arranged primarily by phoneme classes (vowel rules first, then consonants, including stops, nasals, etc.) and secondarily by the type of action represented by the rule (insertion or formation, reduction/deletion, and other variation).

For each group of rules, the following information is presented:

1. A group number and name (chiefly for purposes of cross-reference).
2. A brief characterization of the class of rules included in the group.
3. A list of ARPA-SUR rules classified as belonging to the group. Refer to the List of Sources for an explanation of rule numbers and names.
4. Cross-references to related rules or groups of rules.
5. Comments, including examples and counter-examples (if known) of rule application.

In general, the formal rule specifications have not been given since they are separately available, and to include them would increase the bulk of this paper to an unmanageable extent. Nor has the issue of rule ordering been considered here.

A second portion of this note simply presents a list of all the rules considered, arranged by site and (site-assigned) number, and giving for each rule the number of the group under which it has been classified.

Observations:

It is interesting to note how few of the ARPA-SUR phonological rules are identical. Even rules describing the same phonological process usually specify different environments.

Some of the differences in the rules may be due to the fact that the formulator has not sufficiently restricted, or has over restricted, the environment.

Such differences, however, may not be due to simple carelessness. It is certainly possible that a phonological process may occur frequently in one environment, occasionally in another, and rarely in a third. The question of which of these environments to include in the rule, and how to do so sensibly, then becomes difficult to answer. When this trouble is compounded by differences due to speech rate and style and dialect, it is easy to see why so few of the rules agree on a precise statement of the appropriate environment.

Conclusions:

The rules summarized in this note can be classified into a number of subsets, each describing some reasonably distinct phonological process.

But, to the extent that their use in speech understanding systems requires precise formulation of rule environments and careful measurement of application frequencies, it can be expected that a great deal of research is still ahead of us.

GROUP 1 - SCHWA INSERTION

The rules mentioned here all insert a reduced stress, neutral vowel into a word.

Rules:

BBN-8.1	Schwa Insertion - Stressed Sonorant
UCB-49	[AX] - Insertion I
UBC-50	[AX] - Insertion II
UCB-51	[AX] - Insertion III
UCB-52	[AX] - Insertion IV
UCB-105	[AX] - Insertion

See also:

UCB-14	dipthongization

Comments:

Rules UCB-49, 50, and 105 are probably useful only if inflectional forms are to be derived. They explain, for example, the schwa inserted in the inflectional suffixes for plural or past tense (match + s → matches; raid + d → raided). Alternatively, these rules may be viewed as phonotactic statements. Certain consonant pairs may not occur within a syllable.

The purpose of UCB-51 is to clean up after another rule (UCB-55: [AX] - Syncope II); its environment does not occur in surface forms.

Rules UCB-52 and BBN-8.1 act in different environments. The former inserts schwa between [TH] and [L], as in "athlete" (are there other examples for this rule?). The latter rule inserts schwa between a stressed high vowel (or stressed vowel followed by a glide) and a following liquid or nasal, as in:

pure → P Y UW:1 AX:0 R

The remark that this latter rule may be eliminated by incorporating the schwas in the lexicon is also relevant to UCB-52. The schwas may then be deleted (when inappropriate) by one of the schwa deletion rules in Group 3.

GROUP 2 - VOWEL REDUCTION

These rules describe the neutralization of unstressed vowels; stress reduction rules have also been included.

Stress Reduction:

BBN-1.1	Pre Primary Secondary Stress Reduction
BBN-2.1	Post Primary Secondary Stress Reduction
SDC-2	Unstress Vowel Reduction for Monosyllables

Vowel Reduction:

BBN-3.1	Vowel Reduction
SCRL-1	Vowel Reduction
SDC-1	Vowel Reduction
UCB-45	Vowel Reduction

Allophones of Schwa:

BBN-11.1	Odd Schwa - General Form
BBN-12.1	Dental Odd Schwa
BBN-13.1	Odd Schwa - Vowel Harmony
BBN-14.1	Odd Schwa - Retracted

Comments:

The three stress reduction rules are all different. The SDC-2 rule applies only to monosyllabic words which are entered into the lexicon with unstressed (but not reduced) vowels. (There is a difference of terminology about whether the lowest degree of stress is called unstressed or reduced.) The two BBN rules apply only to polysyllabic words (and possibly fixed syntactic phrases) in which syllables other than the primary stressed one

may have either secondary stress or no stress. All three rules feed the vowel reduction process, and could be eliminated by allowing alternative stress forms in the lexicon.

Of the actual reduction rules, SDC-1 is the simplest, changing any zero stressed vowel to a schwa. The rule can be expected to apply more often in faster speech. UCB-45 is similar, but additionally states that the rule applies more generally to lax than to tense vowels.

The rule BBN-3.1 is similar, but its specification prevents the rule from applying at all to tense high or non-tense low vowels.

SCRL-1 is the only rule which specifies a context; it essentially says that a prevocalic vowel is never reduced, and two reduced syllables cannot be adjacent, even if in separate words. All examples given for all four reduction rules satisfy the environment of SCRL-1, which is close to, though not the same, as that specified in the stress reduction rules BBN-1.1 and 2.1.

SCRL-1 also states that a reduced vowel may be realized as [AX], [IH], or [IX]. This is identical to BBN-11.1. This variation is conditioned by phonological environment and dialect, which is specified in more detail in BBN-12.1, 13.1, and 14.1.

GROUP 3 - VOWEL DELETION

Various aspects of vowel deletion, especially schwa deletion, are covered by the rules listed here.

Rules:

BBN-4.1	Schwa Deletion - Weak String
BBN-5.1	Schwa Deletion - Weak Syllable
BBN-6.1	Schwa Deletion - Stressed Glide
BBN-9.1	Dropped Open Syllable Rule
BBN-70.1	Syllabic Liquid Recovery
CMU-9.2 CMU-9.3	Schwa Loss
Lincoln-1	Schwa Deletion I
Lincoln-2	Schwa Deletion II
Lincoln-3	Schwa Deletion III
SCRL-2	[AX] Deletion
SDC-4	Reduced Vowel Deletion - Preconsonantal
SDC-5	Reduced Vowel Deletion - Non-Preconsonantal
SDC-23	Syllable Deletion
UCB-54	[AX] - Syncope I
UCB-55	[AX] - Syncope II

See also:

Group 4	Syllabification
Group 21	Ruh Reduction/Loss
BBN-36.1	[IY] Gliding
SDC-19	Weak Syllable Deletion
SDC-20	Syllabic [R] - Reduction

UCB-20 Glide Formation

Comments:

The rather large number of rules grouped here apparently represent several different processes.

The rules BBN-9.1 and SDC-23 change syllabic consonants to non-syllabic consonants pre-vocalically, especially in fast speech, as in "binary" [B AY N ER IY → B AY N R I]. The SDC rule applies only to the syllabic [ER] and requires a consonant to precede the syllabic consonant. Perhaps "theory" [TH IY R IY] is a counter-example to this latter constraint.

The remaining rules all deal with schwa deletion. BBN-70.1 is an analytic rule which reflects the low of a schwa in syllabification (see Group 4 - Syllabification).

The deletion of the schwa in words like "police" [P L IY S] and "balloon" [B L UW N] will result from Lincoln-3, SCRL-2, and UCB-55. Additionally, UCB-55 explains the deletion of schwa in "about" [B AW T]. The SCRL rule does not explain words like "potato" [P T EY T OW] or "display" [D S P L EY] claimed as examples for the UCB and Lincoln rules (note that these examples violate the word initial consonant cluster constraints of SCRL-28).

Lincoln-2 accounts for "potato", and also for "multiply" [M AH L T P L AY], but not for the other four examples mentioned in the preceding paragraph. Derivations of "moppet" [*M AA P T] and "typography" [*T P AA G R AX F IY] seem to be counter-examples to this rule.

The four rules BBN-5.1, BBN-6.1, CMU-9.2, and SDC-5 explain post-vocalic schwa deletion as in "violet" [V AY L AX T] or "the academy" [DH IY K AE M IY] (not explained by SDC-5).

The remaining rules, BBN-4.1, Lincoln-1, SDC-4, and UCB-54, as well as SCRL-2, and BBN-5.1, (already mentioned above), describe post-consonantal schwa deletion. These rules all explain words like "chocolate" [CH AO K L AX T] or "arsenal" [AA R S N AX L]. Rule UCB-54 fails (in spite of its claims) on "general" [JH EN R AX L] and "interest" [IH N T R EH S T], for which the other rules succeed.

However, SDC-4 specifies a syllable boundary before the schwa, so that its application to "arsenal" and "interest" requires the base forms be given the unusual syllabifications "ars*e*nal" and "int*e*rest".

Rules BBN-5.1 (?), Lincoln-1, SCRL-2, and UCB-54 all incorrectly (?) predict that "sentiment" should occur as [S EH N T M AX N T]. A similar counter-example is "percolate".

In summary, it seems that the process of vowel deletion is a rather complex one, not yet well understood.

GROUP 4 - SYLLABIFICATION

A schwa followed by a resonant (or a resonant followed by a schwa) can yield a syllabic resonant.

Rules:

BBN-7.1	Syllabic Sonorant
CMU-9.1	Schwa Loss (Syllabification)
CMU-9.4	Schwa Loss (Syllabic Fricative)
SCRL-4	Syllabicizing
SDC-25	Syllabicizing
UCB-53	[AX] + [N] Coalescence

See also:

Group 21	Ruh Reduction/Loss
BBN-4.1	Schwa Deletion - Weak String
BBN-5.1	Schwa Deletion - Weak Syllable
BBN-6.1	Schwa Deletion - Stressed Glide
BBN-70.1	Syllabic Liquid Recovery

Comments:

The six rules summarized here are all different. The classes of segments undergoing syllabification range from just [N] in the UCB rule, [M], [N], or [L] in the SDC rule (but see also SDC-12 and SDC-24), [M], [N], or liquid in the SCRL rule, to nasal or liquid in the BBN and CMU rules. CMU-9.4 produces a syllabic fricative.

The environments also vary widely. The CMU rule specifies none at all, the SDC and SCRL rules both require that a consonant precede the

schwa, while the UCB rule requires an alveolar stop.

The BBN rule is obligatory, and operates on the output of BBN-4.1, 5.1, and 6.1 (Schwa Deletion) so that it expects no schwa in its input; the other rules all explicitly mention (and delete) the schwa.

GROUP 5 - VOWEL RAISING

Under certain conditions, vowels tend to be higher than normal.

Rules:

BBN-15.1 [EH] - Raising

BBN-16.1 Initial [EH] Raising

BBN-17.1 [AE] - Raising

SCRL-25 [AA] - Raising and Fronting

SCRL-26 [EH] - Raising

Comments:

BBN-15.1 and SCRL-26 are essentially the same, except that the SCRL rule allows raising before any nasal, rather than just before [N] (for example, "democrat" →[D IH M AX K R AE T]).

The other rules all describe different aspects of raising. All five rules are dialectal.

GROUP 6 - OTHER VOWEL PHENOMENA

Miscellaneous rules affecting vowels are included here.

Rules:

BBN-26.1	Apicalized Back Vowel
BBN-27.1	Apicalized Vowels
BBN-28.1	Lateralization of Vowels
BBN-62.1	Umlauting
BBN-63.1	Lowered Front Vowels
CMU-8	Diphthong Reduction
UCB-44	Vowel Laxing before [R]

Comments:

Rules acting on vowels, but not obviously belonging in one of the preceding groups, have been listed here.

BBN-26.1 and 27.1 describe the occurrence of retroflexed vowels before [R]. A vowel before an [L] may also become lateralized (BBN-28.1). BBN-62.1 gives the environment for umlauting, and BBN-63.1 predicts that front vowels will be lowered when adjacent to labials.

CMU-8 describes diphthong reduction in unstressed words, and UCB-44 states that vowels may be laxed before a tautosyllabic [R].

GROUP 7 - GLIDE FORMATION

The rules grouped here explain conditions for insertion of glides.

Rules:

BBN-10.1	Glide Epenthesis
BBN-36.1	[IY] Gliding
Lincoln-5	Transitional Glide Insertion I
Lincoln-6	Transitional Glide Insertion II
SDC-19	Weak Syllable Deletion
UCB-14	Diphthongization
UCB-20	Glide Formation

Comments:

The three rules BBN-36.1, SDC-19, and UCB-20 are essentially the same, yielding a [Y] glide in place of a post-consonantal, pre-vocalic [IY]. The stated environments differ somewhat. The SDC rule allows the following vowel to be [AX] or [EH] only, and does not require a preceding consonant. The UCB rule requires a preceding alveolar consonant, and furthermore permits at most one preceding consonant. Not all the examples given with the UCB rule satisfy its stated environment (for example, "California" [K AE L AX F AO R N Y AX] does not). All examples given for any of the three rules appear to satisfy the environments given in the BBN and SDC rules.

The rules BBN-10.1 and Lincoln-5 and 6 specify insertion of inter-vocalic glides. The Lincoln rules allow this only between words, but otherwise the rules are similar in predicting rounded or unrounded glides.

The UCB-14 rule describes similar types of post-vocalic glides, but without stating any environment.

GROUP 8 - GLIDE LOSS

Rules deleting or weakening glides are summarized here.

Rules:

BBN-38.1	Glide Loss
UCB-19	Glide Deletion after Palatals
UCB-21	Glide Vocalization
UCB-22	Glide Weakening

See also:

Group 10	Palatalization
CMU-8	Diphthong Reduction

Comments:

BBN-38.1 and UCB-19 are similar rules, deleting a [Y] glide after a palatal and before a vowel. The UCB rule requires the following vowel to be unstressed, but perhaps the BBN example "fiduciary" [F AX D UW SH EY R IY] disproves this. Both rules are closely connected with the palatalization rules.

The rule UCB-22 weakens glides following a (tautosyllabic) vowel nucleus. UCB-21 deletes glides before stressed vowels, when the glide originally was a vowel. Since this rule simply undoes UCB-20 (Glide Formation), it is not clear that it is needed.

GROUP 9 - GEMINATE REDUCTION

Two identical constants reduce to one across an optional boundary.

Rules:

BBN-47.1	Geminate Reduction
Lincoln-18	Geminate Reduction
SCRL-20	Geminate Reduction
SDC-3	Geminate Reduction
SDC-22	[R] Degemination
SRI-11	Like Phone Shortening
UCB-10	Degemination

Comments:

These rules are all essentially identical in describing the degemination of two like consonants with an optional intervening boundary. For example, "surface speed" becomes [S ER * F AX # S P IY D].

The rule is more frequently applied in fast speech.

The SRI rule, based on speech synthesis rules, predicts that degemination will apply to any pair of identical segments (not just to consonants), and furthermore, that the degeminate pair will have a duration greater than that of a single segment, but less than twice the normal duration.

GROUP 10 - PALATALIZATION

Alveolar consonants may be palatalized, especially when preceding a palatal.

Rules:

BBN-37.1	Affricated Dental
CMU-12	Palatalization
Lincoln-13	Palatalization I
Lincoln-14	Palatalization II
Lincoln-15	Palatalization III
Lincoln-17	Palatalization IV
SCRL-14	Palatalization I
SCRL-15	Palatalization II
SCRL-16	Sibilant Palatalization
SDC-11	Palatalization
UCB-30	Palatalization
UCB-31	Palatalization before [R]
UCB-36	Sibilant Palatalization

See also:

Group 4	Glide Loss
BBN-61.1	Fricative Assimilation

Comments:

The five rules CMU-12, Lincoln-13 and 14, and SCRL-14 and 15 are close to identical. In an environment consisting of an alveolar obstruent followed by an optional word boundary, a [Y] glide, and a vowel, they all

delete the glide and palatalize the obstruent. A classic example is "did you", which becomes [D IH JH UW]. The CMU rules requires the presence of the word boundary, but not of the following vowel.

Three other rules, BBN-37.1, SDC-11, and UCB-30, are similar, but do not delete the glide. This is performed by separate rules (see Group 8 - Glide Loss).

The four rules Lincoln-15 and 17, SCRL-16, and UCB-36 all describe the palatalization of sibilants preceding palatals as in "misuse" [M IH SH UW Z]. The requirement of a following palatal in Lincoln-17, which also requires a preceding [SH] or [ZH] and word boundary, may be a typographical error, as the example contains a following [K]: "refresh screen" becomes [R IY F R EH SH SH K R IY N].

The final rule, UCB-31, palatalizes an alveolar consonant before [R], so that "try" may become [CH R AY].

GROUP 11 - STOP INSERTION

Rules inserting non-glottal stops are summarized here.

Rules:

BBN-39.1 Neutralization after Nasal

Lincoln-11 Homorganic Stop Insertion

Lincoln-12 Epenthetic Stop Insertion

SCRL-19 Transitional Stop Insertion

SDC-10 Homorganic Stop Insertion

UCB-37 Stop Insertion

UCB-47 "Yep" Formation

Comments:

Rules SCRL-19 and SDC-10 both insert a stop homorganic to a preceding nasal before a stop or fricative; if a stop follows, its place of articulation must be different than that of the nasal. The rules account for "prince" becoming [P R IH N T S]. The SDC rule requires both the inserted stop and following stop or fricative to be voiceless, whereas the SCRL rule only requires that they agree in voicing.

UCB-37 allows only a following voiceless fricative (and inserts a voiceless stop); Lincoln-11 is similar, but does not specify voicing for the inserted stop.

BBN-39.1 treats this process somewhat differently; instead of inserting a stop, the fricative is affricated. This is justified on the basis that the "inserted stop" is not really a true stop.

Lincoln-12 inserts a [T] between [L] and [S] (presumably in the same

syllable) to obtain [F AO L T S] from "false".

UCB-47 is a curious rule which inserts a (not necessarily homorganic) unreleased [P] at the end of certain interjections. "No", for example, becomes [N OW P], with the [P] not released.

GROUP 12 - GLOTTAL STOP FORMATION

These rules describe the circumstances under which a glottal stop occurs.

Rules:

BBN-43.1	Cockney [T]
BBN-51.1	Initial Vowel - Stressed
BBN-52.1	Initial Vowel - Unstressed
CMU-2	Word-final [T] goes to Glottal Stop
Lincoln-4	Transitional Stop Insertion I
SCRL-13	Glottal Stop Formation
SDC-28	Glottalization
UCB-23	Glottalization
UCB-48	[Q] - Formation

Comments:

The rules BBN-51.1 and 52.1 describe the realization of a word initial vowel as a glottal stop followed by a vowel. Lincoln-4 is similar, but requires the preceding word to end in a vowel.

UCB-23 states that a voiceless stop may be glottalized in syllable final position following a sonorant.

The remaining rules describe the derivation of a glottal stop from a [T]. CMU-2 requires the [T] to be a word final; UCB-48 (via UCB-23) requires it to be syllable final. SDC-28 requires the [T] to precede a syllabic [N] or [L]; BBN-43.1 and SCRL-13 essentially allow either environment.

The frequency of the rule's application is apparently influenced by the nature of the following segment, occurring for some more frequently before labials.

GROUP 13 - STOP DELETION

Homorganic stop deletion, as well as other aspects of stop deletion, is considered here.

Dental Deletion:

BBN-42.1	Dental Dropping
CMU-1	Word Final [T] Deletion
CMU-3	Word Final [D] Deletion
Lincoln-8	Homorganic Stop Deletion
Lincoln-9	Dental Deletion I
Lincoln-10	Dental Deletion II
SCRL-9	Dental Deletion I
SCRL-10	Dental Deletion II
SCRL-11	Dental Deletion III
SDC-8	Dental Deletion - Voiced
SDC-9	Dental Deletion - Voiceless
SRI-1	[T], [D] Deletion
SRI-3	[T], [D] Deletion: Specific
UCB-9	[D] - Deletion
UCB-41	[T] - Deletion

Unreleased Consonants:

BBN-41.1	Unreleased Stop
UCB-6	Consonant Unrelease I
UCB-7	Consonant Unrelease II

Other Stop Deletion:

BBN-40.1	[K] Loss
BBN-72.1	Initial Fricative - Aspirate
BBN-76.1	Final [S]
SRI-2	Final Consonant Deletion
UCB-17	[G] - Deletion I
UCB-18	[G] - Deletion II

See also:

Group 24	<-ing> Reduction
BBN-39.1	Neutralization after Nasal
UCB-3	Approximant

Comments:

The deletion of [T] in environments like "act courageous" [AE K K AX R EY JH AX S] or "twenty" [T W EH N IY], and of [D] from "told" [T OW L] or "kindness" [K AY NN AX S] represents the sort of processes described by the relatively large number of dental deletion rules.

The rules Lincoln-9 and UCB-41 are duplicates, as are Lincoln-10 and UCB-9, but all the others are different. Some delete [T]'s, others delete [D]'s, while still others attempt to account for both in a single rule. Again, some of the rules delete only word final stops, while others delete non-final stops as well.

The wide range of environments given may result from lumping together several different processes. Also, the frequency of deletion is affected by the environment so that some of the rule specifications may represent

different points along a continuum from "never applying" to "obligatory application". Variable rules such as SRI-1 and 3 attempt to describe this variation in deletion frequencies in systematic terms.

A somewhat different approach is represented by rules BBN-41.1 and UCB-6 and 7, which claim that, in some cases, the stop is not entirely deleted, but is instead unreleased. The BBN rule states that the [P] in "apt" cannot be unreleased (in English); UCB-6 makes the [P]'s unrelease obligatory.

Of the other stop deletion rules (which do not delete dental stops only), BBN-72.1 and 76.1 are analytic rules which reflect the difficulty of detecting post-pausal aspirated voiceless stops or voiceless stops following an [S] before a pause. BBN-46.1 describes some [K] and [G] deletion; UCB-17 and 18 are [G] deletion rules which might be best incorporated into the lexicon.

SRI-2 sums up universal tendencies in word final consonant deletion: deletion is more frequent when a consonant precedes it, when a vowel does not follow, and when it is not a separate morpheme.

GROUP 14 - ASPIRATION

The aspiration of voiceless stops is the subject of the rules listed here.

Rules:

BBN-55.1 Stressed Aspirated Stops

BBN-56.1 Initial Aspirated Stops

BBN-57.1 Medial Unstressed Aspirated Stops

BBN-67.1 "Staspask" Rule

UCB-4 Aspiration

See also:

BBN-60.1 Source Assimilation

Comments:

BBN-67.1 treats voiceless stops as basically aspirated, and gives an environment in which this aspiration is lost. The UCB rule treats stops as underlyingly unaspirated, and, in an environment not quite complementary to that of the BBN rule, adds aspiration.

The BBN rules 55.1 through 57.1 discuss degrees of aspiration from heavy to slight.

GROUP 15 - ALVEOLAR FLAPPING

The conditions for alveolar flap formation are detailed by these rules.

Rules:

BBN-33.1	Flapping
CMU-10	Flapping
Lincoln-7	Alveolar Stop Flapping
SCRL-12	Alveolar Flapping
SDC-6	Alveolar Flapping - Internal
SDC-7	Alveolar Flapping - Inter-word
UCB-38	Tap

Comments:

The rules all basically agree that an intervocalic alveolar stop may be realized as a flap when the stress of the preceding vowel is greater than that of the following vowel. For example, "latter" becomes [L AE DX ER]. Several rules also allow the vowels to be equally stressed, if the stress is primary or reduced. CMU-10 and UCB-38 allow the second vowel to have greater stress (though the rule applies less frequently in this environment).

All the rules except BBN-33.1 allow an [R] to intervene between the first vowel and the stop; several allow [N] as well.

CMU-10, Lincoln-7, and UCB-38 derive a flap from [N] as well as from [T] or [D]; CMU-10 also allows an [L] to be flapped.

In spite of the relative agreement of the rule specifications, the authors of BBN-33.1 and UCB-38 imply that flapping is not particularly well understood.

GROUP 16 - FLAP DELETION

Flaps may be deleted on occasion.

Rules:

CMU-11 Flap Deletion

UCB-39 Tap Deletion

Comments:

Under some conditions, a flap may be deleted. Neither rule gives an environment for this rule: an optimal environment is still to be determined. Apparently it is most likely in rapid speech, when, for example, "little" may be realized as [L IH L].

GROUP 17 - VOWEL NASALIZATION

Conditions for the nasalization of vowels are given in the rules listed here.

Rules:

SCRL-7	Vowel Nasalization
SDC-26	Nasalized Vowels
UCB-29	Nasalization

See also:

BBN-44.1	Truncated Nasal
CMU-7	Nasal Dropping

Comments:

The three rules listed here all nasalize vowels which precede nasal consonants; the three rules are identical. BBN-44.1 and CMU-7 (listed in Group 18 - Nasal Deletion) also describe vowel nasalization.

GROUP 18 - NASAL DELETION

These rules treat the deletion of nasal consonants.

Rules:

BBN-44.1	Truncated Nasal
BBN-78.1	Nasal Insertion
CMU-7	Nasal Dropping
SCRL-8	Nasal Consonant Deletion
SDC-27	Nasal Consonant Deletion
UCB-28	Nasal Deletion

Comments:

BBN-78.1 is an analytic rule which inserts a nasal consonant where it could have been deleted by a generative rule. Since vowel nasalization is apparently not detected, this turns out to be between any vowel and a following (non-nasal?) consonant.

The remaining rules generatively specify the deletion of a nasal between a nasalized vowel and a following consonant. BBN-44.1 requires the following consonant to be non-nasal; UCB-28 requires it to be a voiceless stop. The SDC rule requires a word or syllable boundary after the following consonant, while CMU-7 and SCRL-8 permit, but do not require, a word boundary before the consonant. Linda Shockey (CMU) states that of 3 subjects, only one extended this process across word boundaries.

Rules BBN-44.1 and CMU-7 both assert that the process of nasal deletion is a graduated one. The preceding vowel may take on various degrees of nasalization, and the nasal consonant can be shortened rather than being deleted entirely.

GROUP 19 - NASAL ASSIMILATION

Nasals may assimilate in place of articulation to neighboring consonants.

Regressive Assimilation:

BBN-45.1 Nasal Assimilation

SCRL-17b Regressive Assimilation (of place)

SDC-14 Regressive Nasal Assimilation

UCB-43 Velar Nasal

Progressive Assimilation:

SCRL-18b Progressive Assimilation (of place)

UCB-40 Tap Nasalization

Comments:

BBN-45.1, SCRL-17b, and SDC-14 are close to identical in stating that a nasal may assume the place of articulation of a following consonant, with optional intervening word or syllable boundary. The SDC rule additionally requires that the following consonant not be a sonorant. UCB-43 is a more restriced rule, velarizing [N] before velars; it claims the process is obligatory unless the [N] is in an unstressed syllable and the velar precedes the main stress.

A claimed counter-example to SCRL-17b, "hypnotize", is incorrect, since the word does not satisfy the rule's environment.

The rule SCRL-18b states that a nasal may also be assimilated to a preceding consonant, as in "hypnotize" [HH IH P M AX T AY Z], but this rule

apparently requires further constraints to prevent its application in other cases.

UCB-40 nasalizes a tap following a nasalized vowel; the rule is claimed to be obligatory for some speakers.

GROUP 22 - R/L PHENOMENA

Rules affecting the liquids have been collected under this heading.

Insertion and deletion:

BBN-31.1	Lost [R]
Lincoln-19	[R] Deletion
Lincoln-20	[R] Insertion
SCRL-24	[R] Deletion before Dentals
SDC-18	Lateral Deletion
SDC-20	Syllabic [R] Reduction
UCB-33	[R] / [L] Deletion

Variation:

BBN-18.1	Archaic [R]
BBN-19.1	Initial [R]
BBN-20.1	Velarized [R]
BBN-29.1	Velarized [L]
BBN-30.1	Retroflexed Consonants
SCRL-21	Dark [L]
SCRL-22	[R]-Flapping
SCRL-23	[R]-Devoicing
SDC-17	Velarization
UCB-32	[R] /[L] Coloring
UCB-34	[R] Tap or Trill

GROUP 20 - FRICATIVE AND SIBILANT RULES

Rules affecting fricative and sibilant segments are summarized here.

Formation and deletion:

BBN-46.1	[V] Assimilation
BBN-64.1	"Nis - Here" Rule
CMU-5	[V] Dropping
UCB-11	Dental [S]
UCB-15	[F TH] Simplification

Variation:

BBN-49.1	Stressed (Labio-) Dental Fricative
BBN-61.1	Fricative Assimilation
CMU-13	[DH] Assimilation
Lincoln-16	Sibilant Fronting
UCB-1	Affrication
UCB-3	Approximant
UCB-5	[CH] Simplification
UCB-35	Sibilant Fronting

See also:

BBN-48.1	Spirant Voicing
SDC-21	Fricative Voicing
UCB-106	Ungeminate [S]-Voicing

Comments:

BBN-46.1 and CMU-5 both delete [V] preceding an optional word boundary and [M] as in "give me" [G IH M IY]. The CMU rule, in fact, allows any consonant to follow, so that, for example, "of" could become [AX].

BBN-64.1 changes [DH] to an [N] or [Z] following an [N] or [Z] and a word boundary. It would change "in this" to [IH N # N IH S].

UCB-11 simplifies a [(S) TH S] cluster to a dental [S], as in "sixths"; UCB-15 changes an [F TH] cluster to a [TH] or [F] preceding a vowel or consonant, respectively.

BBN-49.1 and UCB.1 are both affrication rules, but otherwise quite different.

Lincoln-16 and UCB-35 both change [SH] or [ZH] to [S] or [Z] before [S] or [Z], respectively, though the specification of an environment is more detailed in the Lincoln rule. BBN-61.1 is similar, but also changes [S] or [Z] to [SH] or [ZH] before [SH] or [ZH] (a palatalization rule).

CMU-13 describes the assimilation of [DH] to a preceding alveolar consonant or [M] or [V] (so that "that's the" can become [DH AE S AX]); UCB-3 changes voiced stops to approximants; UCB-5 describes the assimilation of a [CH] to a preceding [SH].

GROUP 21 - RUH REDUCTION/LOSS

The two processes of ruh reduction and ruhlessness are grouped here.

Ruh reduction:

SCRL-5	Ruh Reduction
SDC-12	Ruh Reduction
SDC-24	Initial Ruh Reduction

Ruhlessness:

BBN-21.1	Ruhlessness - General Form - Echoic
BBN-22.1	Ruhlessness - General Form - Anticipatory
BBN-23.1	Ruhlessness - Exact - Echoic
BBN-24.1	Ruhlessness - Exact - Anticipatory
BBN-25.1	Ruhlessness - Exact - Light [R]
SCRL-6	Ruhlessness
SDC-13	Ruhlessness

Comments:

SDC-24 changes a word initial syllable consisting of [R] followed by any unstressed vowel to [ER]; SCRL-5 and SDC-12 similarly produce [ER] from [R AX] in other environments - these environments are partially contradictory.

SCRL-6 and SDC-13 both change unstressed [ER] to [AX] interconsonantally. BBN rules 21.1 through 25.1 describe the environments for loss of [R] or [ER] in more detail.

See also:

Group 21 Ruh Reduction/Loss

SDC-22 [R] Degemination

Comments:

Many of the rules summarized here are dialectal in nature.

Rules BBN-31.1, Lincoln-19, and SCRL-24 all delete [R] in essentially different environments. SDC-18 deletes [L] in words like "dolphin" [D AO * F IH N].UCB-33 deletes both [R] and [L], but it is perhaps more appropriate to consider it as one state of a syllabification process (along with UCB-32).

Lincoln-20 and SDC-20 both insert [R], but represent different processes; the SDC rule is more akin to the schwa deletion rule BBN-9.1 (See Group 3 - Schwa Deletion).

BBN-29.1 and SCRL-21 are similar rules, velarizing [L]'s; SDC-17 acts in a similar environment, but changes the [L] to a [W].

Both SCRL-22 and UCB-34 describe [R] flapping, though the environment for the latter rule is somewhat more general.

SCRL-23 devoices [R] following a syllable initial [T] (or voiceless stop?), and is a special case of the rather more complex rules BBN-30.1 and 31.1; these latter rules also act on an [R] following a [D] or [SH], as well as after [T].

The remaining rules (BBN-18.1 through 20.1) describe other variants of [R], and have no counterparts in collections from the other sites.

GROUP 23 - H PHENOMENA

Rules affecting [HH] are listed here.

Deletion:

BBN-65.1	"Which - Wich" Rule
SCRL-27	[HH]-Deletion
UCB-24	[HH]-Deletion

Variation:

BBN-50.1	Breathy Voice
UCB-16	"Did he do it?"
UCB-25	[HH]-Voicing

Comments:

The three deletion rules act in different environments, and all three are dialectally conditioned. BBN-65.1 describes the failure to distinguish "wh" and "w", so that, for example, "which" and "witch" are identical in some dialects. SCRL-27 describes the loss of word initial [HH] before [Y UW] as in "humid" [Y UW M IH D]. UCB-24 represents loss of [HH] before an unstressed vowel as in "vehicle" [V IY IH K AX L] -- this might be best incorporated into the lexicon.

Of the other two rules, BBN-50.1 explains the coarticulation effects in transition from an [HH] to a vowel, and UCB-25 predicts that [HH] will become voiced between a voiced segment and a stressed vowel. UCB-16 is a rule fragment.

GROUP 24 - ⟨-ING⟩ REDUCTION

The word final morpheme "ing" is changed to "in".

Rules:

CMU-4 "Dropping the [G]"

SCRL-3 Morpheme ⟨-ing⟩ Reduction

SDC-16 ⟨-ing⟩

See also:

UCB-17 [G] Deletion I

UCB-18 [G] Deletion II

Comments:

The rules all reduce a word final "-ing" morpheme to something like IH N, as in "going" G OW * IH N. Linda Shockey (CMU) notes that the reduction may occur only with present participles (but not gerunds), at least in some dialects.

The SCRL rule does not require that the "ing" be word final (so that the rule would apply to "singer"), but even that restriction is apparently not sufficient, since all three rules, as stated, would incorrectly apply to "sing", "ring", etc.

Both the above comments apparently indicate that a phonological rules pass in a speech understanding system might require access to syntactic or morphological information for optimal functioning.

A similar reduction occurs in words ending in "-thing", as in "something".

GROUP 25 - OTHER CONSONANT RULES

Other ARPA-SUR rules affecting consonants are collected here.

Rules:

BBN-34.1	Weak Labials and Dentals
BBN-35.1	Palatial [K]
BBN-71.1	Initial [L]
BBN-73.1	Initial [R]
BBN-74.1	Initial Vowel
BBN-75.1	Final Vowel
BBN-77.1	Final Nasal
UCB-12	Dental [T], [D], [N]
UCB-42	Velar Fronting
UCB-46	[W]-Deletion

Comments:

Rules here are a miscellaneous collection of rules acting on consonants, which did not obviously belong to any of the preceding groups.

Rules BBN-35.1 and UCB-42 both describe the fronting of a velar consonant, though the former rule specifies the process in much greater detail.

The BBN rules 71.1, 73.1, 74.1, 75.1, and 77.1 are all analytic rules. They account for the loss or weakening (from the point of view of an acoustic front-end) of various classes of consonants in certain environments.

GROUP 26 - VOICING

Rules which voice or devoice segments are combined into this group.

Rules:

BBN-48.1	Spirant Voicing
BBN-58.1	Word Final Laxing
BBN-59.1	Tensed Voiced Stop
BBN-60.1	Source Assimilation
BBN-66.1	Voiceless Syllable
CMU-6	Marginal Devoicing
CMU-9.3	Schwa Loss (Aspiration + Schwa)
SCRL-17a	Regressive Assimilation (of voicing)
SCRL-18a	Progressive Assimilation (of voicing)
SDC-15	Progressive Assimilation of voicing
SDC-21	Fricative Voicing
UCB-13	Devoicing
UCB-106	Ungeminate [S]-Voicing

See also:

BBN-31.1	Lost [R]
SCRL-23	[R]-Devoicing
UCB-25	[HH]-Voicing

Comments:

The intervocalic voicing of [S] or [SH] is covered by rules BBN-48.1, SDC-21, and UCB-106, although the exact form of these rules differs.

CMU-6 devoices word initial or final obstruents; BBN-58.1 and 59.1 extends this rule to any consonant (?) and describes the exact process in

more detail. UCB-13 applies only to word final obstruents.

Both BBN-66.1 and CMU-6 devoice schwa, although in dissimilar environments, thereby creating voiceless syllables.

Regressive assimilation of voicing, so that, for example, "have to" becomes [HH AE F # T AX], is specified identically by (subrules of) BBN-60.1 and SCRL-17.

Progressive assimilation of voicing is exemplified by the realization of "ex-director: as [EH K S # T IH R EH K T ER], which SCRL-18 produces. However, the same rule incorrectly derives *[AE Z # V AA R] from "as for". SDC-15, with a different specification, avoids the latter derivation, but also fails to produce the first one.

GROUP 27 - DURATION RULES

Various deviations from normal segmental duration as a result of phonological environment are covered by the rules listed here.

Rules:

BBN-53.1	Final Vowel
BBN-54.1	Final Consonant
SRI-4	Stressed Vowel Shortening
SRI-5	Heavy Boundary Lengthening
SRI-6	Vowel Unvoiced Plosive Shortening
SRI-7	Vowel Voiced Fricative Lengthening
SRI-8	Vowel Halving
SRI-9	Pre-stressed Cluster Duration
SRI-10	Homorganic Nasal Stop Duration

See also:

BBN-44.1	Truncated Nasal
BBN-55.1	Stressed Aspirated Stops
BBN-57.1	Medial Unstressed Aspirated Stops

Comments:

The rule SRI-5 predicts the lengthening of the vowel and all following segments most immediately preceding a "heavy boundary" by a factor of 50%. Rules BBN-53.1 and 54.1 predict a lengthening 2 to 10 times as great for an utterance final consonant or vowel.

The rule UCB-26 predicts vowel lengthening before voiced obstruents with optional intervening sonorants, while SRI-6, taking the opposite point of view, predicts shorter vowels before voiceless stops. Apparently

in contradiction to UCB-26, SRI-8 specifies vowel shortening before [L] or [R] followed by any consonant.

UCB-27 lengthens low vowels in monosyllabic words; SRI-4 shortens all stressed vowels in the complementary environment of polysyllabic words.

GROUP 28 - PHONOTACTICS

These rules represent constraints on the permissible sequences of phonemes within English.

Rules:

BBN-68.1	Big Cluster
BBN-69.1	Big Syllable
SCRL-28	Consonant Clusters Phonotactics I
SCRL-29	Consonant Clusters Phonotactics II

Comments:

The four rules are all different. The two BBN rules state constraints on the occurrence of large consonant clusters within a single word. The two SCRL rules specify some of the characteristics of word initial consonant clusters.

GROUP 29 - MISCELLANEOUS RULES

All ARPA-SUR rules not so far listed under any group are named here.

Rules:

UCB-2	"An" Selection
UCB-8	Contraction
UCB-101	Vowel Readjustments
UCB-102	Accent Rules
UCB-103	[G] Deletion
UCB-104	Internal Word Boundary Deletion
UCB-201	Copula Contraction
UCB-202	Copula Deletion

Comments:

Rules grouped here are either derivational in nature, or perhaps best incorporated into a speech understanding system in some other way.

One of the problems it will be necessary to face up to is what to do with rules like UCB-201 and 202. These rules for copula contraction and deletion, are representative of a variety of rules which may be conditioned both by phonological and by syntactic environments. Incorporation of such rules into a system could easily prove to be troublesome.

LIST OF SOURCES

Throughout this note, rules are referred to by a "site id" which includes a site "name" and a rule number. These site names are listed below with bibliographic information about the collection of rules from that site.

In some cases, the rules are new contributions; in other cases, the collections are compilations of rules from previous sources. No attempt is made here to credit the original author of a rule.

1. Oshika, Beatrice T., Victor W. Zue, Rollin V. Weeks, Helene Neu, and Joseph Aurbach. "The Role of Phonological Rules in Speech Understanding Research," in Contributed Papers of IEEE Symposium on Speech Recognition. Computer Science Department, Carnegie-Mellon University, Pittsburgh, Pa. April 15 - 19, 1974.

2. BBN
   Colarusso, John. Phonological Rules for Continuous Speech. SUR Note #133, NIC #30487. Bolt, Beranek, & Newman, Inc., Cambridge, Ma. April 26, 1974.

3. CMU
   Shockey, Linda. (Untitled collection of rules.) Carnegie-Mellon University, Pittsburgh, Pa. February, 1974.

4. Lincoln
   Zue, Victor W. Optional Phonological Rules. SUR Note #124, NIC #21952. MIT Lincoln Laboratory, Lexington, Ma. February 19, 1974.

5. SCRL
   Neu, Helene and Beatrice T. Oshika. Optional Phonlogical Rules - Revisions and Additions. SUR Note #122, NIC #21717. Speech Communications Research Laboratory, Santa Barbara, Ca. February 5, 1974.

6. SDC
   Weeks, R. V. SDC Phonological Rules. SUR Note #119, NIC #21490. System Development Corporation, Santa Moniva, Ca. January 31, 1974.

7. SRI
Robinson, Jane. SRI Phonological Rules. SUR Note #123, NIC #21905. Stanford Research Institute, Menlo Park, Ca. February 14, 1974.

8. UCB
Cole, Alan. (Untitled collection of rules.) University of California, Berkeley, Ca. February, 1974.

Index of ARPA-SUR Phonological Rules by Site

Bolt Beranek and Newman (BBN)

ID	GROUP	NAME
BBN-1.1	02	Pre Primary Secondary Stress Reduction
BBN-2.1	02	Post Primary Secondary Stress Reduction
BBN-3.1	02	Vowel Reduction
BBN-4.1	03	Schwa Deletion - Weak String
BBN-5.1	03	Schwa Deletion - Weak Syllable
BBN-6.1	03	Schwa Deletion - Stressed Glide
BBN-7.1	04	Syllabic Sonorant
BBN-8.1	01	Schwa Insertion - Stressed Sonorant
BBN-9.1	03	Dropped Open Syllable Rule
BBN-10.1	07	Glide Epenthesis
BBN-11.1	02	Odd Schwa - General Form
BBN-12.1	02	Dental Odd Schwa
BBN-13.1	02	Odd Schwa - Vowel Harmony
BBN-14.1	02	Odd Schwa - Retracted
BBN-15.1	05	[EH] - Raising
BBN-16.1	05	Initial [EH] Raising
BBN-17.1	05	[AE] - Raising
BBN-18.1	22	Archaic [R]
BBN-19.1	22	Initial [R]
BBN-20.1	22	Velarized [R]
BBN-21.1	21	Ruhlessness - General Form - Echoic
BBN-22.1	21	Ruhlessness - General Form - Anticipatory
BBN-23.1	21	Ruhlessness - Exact - Echoic
BBN-24.1	21	Ruhlessness - Exact - Anticipatory
BBN-25.1	21	Ruhlessness - Exact - Light [R]
BBN-26.1	06	Apicalized Back Vowel
BBN-27.1	06	Apicalized Vowels
BBN-28.1	06	Lateralization of Vowels
BBN-29.1	22	Velarized [L]
BBN-30.1	22	Retroflexed Consonants
BBN-31.1	22	Lost [R]
BBN-32.1	25	Truncated Sonorants
BBN-33.1	15	Flapping
BBN-34.1	25	Weak Labials and Dentals
BBN-35.1	25	Palatal [K]
BBN-36.1	07	[IY] Gliding
BBN-37.1	10	Affricated Dental
BBN-38.1	08	Glide Loss
BBN-39.1	11	Neutralization after Nasal
BBN-40.1	13	[K] Loss
BBN-41.1	13	Unreleased Stop
BBN-42.1	13	Dental Dropping
BBN-43.1	12	Cockney [T]
BBN-44.1	18	Truncated Nasal
BBN-45.1	19	Nasal Assimilation
BBN-46.1	20	[V] Assimilation
BBN-47.1	09	Geminate Reduction

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BBN-48.1	26	Spirant Voicing
BBN-49.1	20	Stressed (Labio-) Dental Fricatives
BBN-50.1	23	Breathy Voice
BBN-51.1	12	Initial Vowel - Stressed
BBN-52.1	12	Initial Vowel - Unstressed
BBN-53.1	27	Final Vowel
BBN-54.1	27	Final Consonant
BBN-55.1	14	Stressed Aspirated Stops
BBN-56.1	14	Initial Aspirated Stops
BBN-57.1	14	Medial Unstressed Aspirated Stops
BBN-58.1	26	Word Final Laxing
BBN-59.1	26	Tensed Voiced Stop
BBN-60.1	26	Source Assimilation
BBN-61.1	20	Fricative Assimilation
BBN-62.1	06	Umlauting
BBN-63.1	06	Lowered Front Vowels
BBN-64.1	20	"Nis - Here" Rule
BBN-65.1	23	"Which - Wich" Rule
BBN-66.1	26	Voiceless Syllable
BBN-67.1	14	"Stasfask" Rule
BBN-68.1	28	Big Cluster
BBN-69.1	28	Big Syllable
BBN-70.1	03	Syllabic Liquid Recovery
BBN-71.1	25	Initial [L]
BBN-72.1	13	Initial Fricative - Aspirate
BBN-73.1	25	Initial [R]
BBN-74.1	25	Initial Vowel
BBN-75.1	25	Final Vowel
BBN-76.1	13	Final [S]
BBN-77.1	25	Final Nasal
BBN-78.1	18	Nasal Insertion

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Carnegie-Mellon University (CMU)

ID	GROUP	NAME
CMU-1	13	Word-final [T]-deletion
CMU-2	12	Word-final [T] goes to glottal stop
CMU-3	13	Word-final [D]-deletion
CMU-4	24	"Dropping the [G]"
CMU-5	20	[V] dropping
CMU-6	26	Marginal devoicing
CMU-7	18	Nasal dropping
CMU-8	06	Diphthong reduction
CMU-9	3,4,26	Schwa loss
CMU-10	15	Flapping
CMU-11	16	Flap deletion
CMU-12	10	Palatalization
CMU-13	20	[DH]-assimilation

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Lincoln Laboratories (Lincoln)

ID	GROUP	NAME
Lincoln-1	03	Schwa Deletion I
Lincoln-2	03	Schwa Deletion II
Lincoln-3	03	Schwa Deletion III
Lincoln-4	12	Transitional Stop Insertion I
Lincoln-5	07	Transitional Glide Insertion I
Lincoln-6	07	Transitional Glide Insertion II
Lincoln-7	15	Alveolar Stop Flapping
Lincoln-8	13	Homorganic Stop Deletion
Lincoln-9	13	Dental Deletion I
Lincoln-10	13	Dental Deletion II
Lincoln-11	11	Homorganic Stop Insertion
Lincoln-12	11	Epenthetic Stop Insertion
Lincoln-13	10	Palatalization I
Lincoln-14	10	Palatalization II
Lincoln-15	10	Palatalization III
Lincoln-16	20	Sibilant Fronting
Lincoln-17	10	Palatalization IV
Lincoln-18	09	Geminate Reduction
Lincoln-19	22	[R] Deletion
Lincoln-20	22	[R] Insertion

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Speech Communications Research Laboratory (SCRL)

ID	GROUP	NAME
SCRL-1	02	Vowel Reduction
SCRL-2	03	[AX] Deletion
SCRL-3	24	Morpheme <-ing> Reduction
SCRL-4	04	Syllabicizing
SCRL-5	21	Ruh-Reduction
SCRL-6	21	Ruh-Lessness
SCRL-7	17	Vowel Nasalization
SCRL-8	18	Nasal Consonant Deletion
SCRL-9	13	Dental Deletion I
SCRL-10	13	Dental Deletion II
SCRL-11	13	Dental Deletion III
SCRL-12	15	Alveolar Flapping
SCRL-13	12	Glottal Stop Formation
SCRL-14	10	Palatalization I
SCRL-15	10	Palatalization II
SCRL-16	10	Sibilant Palatalization
SCRL-17	19,26	Regressive Assimilation
SCRL-18	19,26	Progressive Assimilation
SCRL-19	11	Transitional Stop Insertion
SCRL-20	09	Geminate Reduction
SCRL-21	22	Dark [L]
SCRL-22	22	[R]-Flapping
SCRL-23	22	[R]-Devoicing
SCRL-24	22	[R]-Deletion before Dentals
SCRL-25	05	[AA]-Raising and Fronting
SCRL-26	05	[EH]-Raising
SCRL-27	23	[HH]-Deletion
SCRL-28	28	Consonant Clusters Phonotactics I
SCRL-29	28	Consonant Clusters Phonotactics II

Index of ARPA-SUR Phonological Rules by Site

System Development Corporation (SDC)

ID	GROUP	NAME
SDC-1	02	Vowel Reduction
SDC-2	02	Unstress Vowel Reduction for Monosyllables
SDC-3	09	Geminate Reduction
SDC-4	03	Reduced Vowel Deletion - Preconsonantal
SDC-5	03	Reduced Vowel Deletion - Non-Preconsonantal
SDC-6	15	Alveolar Flapping - Internal
SDC-7	15	Alveolar Flapping - Inter-word
SDC-8	13	Dental Deletion - Voiced
SDC-9	13	Dental Deletion - Voiceless
SDC-10	11	Homorganic Stop Insertion
SDC-11	10	Palatalization
SDC-12	21	Ruh-Reduction
SDC-13	21	Ruh-Lessness
SDC-14	19	Regressive Nasal Assimilation
SDC-15	26	Progressive Assimilation of Voicing
SDC-16	24	<-ing>
SDC-17	22	Velarization
SDC-18	22	Lateral Deletion
SDC-19	07	Weak Syllable Deletion
SDC-20	22	Syllabic [R]-Reduction
SDC-21	26	Fricative Voicing
SDC-22	09	[R] Degemination
SDC-23	03	Syllable Deletion
SDC-24	21	Initial Ruh-Reduction
SDC-25	04	Syllabicizing
SDC-26	17	Nasalized Vowels
SDC-27	18	Nasal Consonant Deletion
SDC-28	12	Glottalization

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Stanford Research Institute (SRI)

ID	GROUP	NAME
SRI-1	13	[T], [D] Deletion
SRI-2	13	Final Consonant Deletion
SRI-3	13	[T], [D] Deletion: Specific
SRI-4	27	Stressed Vowel Shortening
SRI-5	27	Heavy Boundary Lengthening
SRI-6	27	Vowel Unvoiced Plosive Shortening
SRI-7	27	Vowel Voiced Fricative Lengthening
SRI-8	27	Vowel Halving
SRI-9	27	Pre-stressed Cluster Duration
SRI-10	27	Homorganic Nasal Stop Duration
SRI-11	09	Like Phone Shortening

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University of California at Berkeley (UCB)

ID	GROUP	NAME
UCB-1	20	Affrication
UCB-2	29	"an"-Selection
UCB-3	20	Approximant
UCB-4	14	Aspiration
UCB-5	20	Simplification of [ch]
UCB-6	13	Consonant Unrelease I
UCB-7	13	Consonant Unrelease II
UCB-8	29	Contraction
UCB-9	13	[d]-Deletion
UCB-10	09	Degemination
UCB-11	20	Dental [s]
UCB-12	25	Dental [t], [d], [n]
UCB-13	26	Devoicing
UCB-14	07	Diphthongization
UCB-15	20	[f th]-Simplification
UCB-16	23	"Did he do it"
UCB-17	13	[g]-Deletion I
UCB-18	13	[g]-Deletion II
UCB-19	08	Glide Deletion after Palatals
UCB-20	07	Glide Formation
UCB-21	08	Glide Vocalization
UCB-22	08	Glide Weakening
UCB-23	12	Glottalization
UCB-24	23	[hh]-Deletion
UCB-25	23	[hh]-Voicing
UCB-26	27	Length
UCB-27	27	Lengthening of Low Vowels in Monosyllables
UCB-28	18	Nasal Deletion
UCB-29	17	Nasalization
UCB-30	10	Palatalization
UCB-31	10	Palatalization before [r]
UCB-32	22	[r]/[l]-Coloring
UCB-33	22	[r]/[l]-Deletion
UCB-34	22	[r]-Tap or Trill
UCB-35	20	Sibilant Fronting
UCB-36	10	Sibilant Palatalization
UCB-37	11	Stop Insertion
UCB-38	15	Tap
UCB-39	16	Tap Deletion
UCB-40	19	Tap Nasalization
UCB-41	13	[t]-Deletion
UCB-42	25	Velar Fronting
UCB-43	19	Velar Nasal
UCB-44	06	Vowel Laxing before [r]
UCB-45	02	Vowel Reduction
UCB-46	25	[w]-Deletion
UCB-47	11	"Yep" Formation

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UCB-48	12	[D]-Formation
UCB-49	01	[AX]-Insertion I
UCB-50	01	[AX]-Insertion II
UCB-51	01	[AX]-Insertion III
UCB-52	01	[AX]-Insertion IV
UCB-53	04	[AX]+[N] - Coalescence
UCB-54	03	[AX]-Syncope I
UCB-55	03	[AX]-Syncope II
UCB-101	29	Vowel readjustments
UCB-102	29	Accent rules
UCB-103	29	[G]-Deletion
UCB-104	29	Internal word boundary Deletion
UCB-105	01	[AX]-Insertion
UCB-106	26	Ungeminate [S]-voicing
UCB-201	29	Copula Contraction
UCB-202	29	Copula Deletion