26. Schwa

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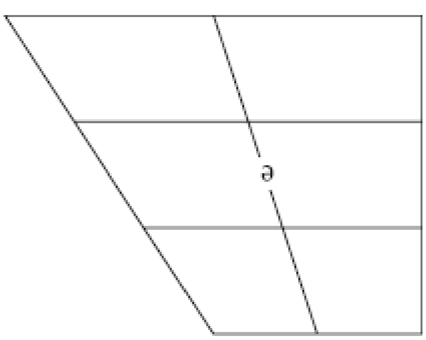
Sections

1 Introduction

Inspection of the chart of the International Phonetic Alphabet (IPA) would suggest that schwa is a vowel like any other; a central open-mid/close-mid unrounded vowel, slightly higher than [ɐ], slightly more central than [ʌ]: i.e. [ə]. Indeed, as the IPA chart necessarily provides idealized phonetic descriptions of its symbols, then, articulatorily speaking, schwa-qua-schwa is just as the IPA chart indicates, as in (1).

(1)



In practice, however, the label "schwa" has been applied to a phonological value that is especially variable in its phonetic properties. In terms of their quality, vowels labeled "schwa" vary to the extent of encompassing a large portion of the vowel space, while tending to gravitate toward the center of this space (see e.g. **Browman and Goldstein 1992** for English schwa). This variability is usually a consequence of schwa's context: flanking consonants and vowels may have a significant co-articulatory influence on schwa's phonetic starting and ending postures, typically far more co-articulatory influence than on vowels of other qualities. In terms of duration – a phonetic property that the IPA vowel chart does not indicate – schwa is typically quite short, and this short duration may co-vary with its tendency to be co-articulated.

In acoustic terms, schwa's resonance structure may be modeled (as a first approximation) by a tube that has no significant constrictions anywhere along its length, such that its formants derive not from two tubes (and/or a Helmholtz resonator) as is the case for other vowels, but instead from one long tube (see e.g. **Johnson 2003**). Given a tube that approximates the length of an adult male vocal tract, this idealized version of schwa possesses formants at 500 Hz, 1500 Hz, 3500 Hz, etc. (**Johnson 2003**). However, since schwa's articulatory properties are so variable – typically, far more variable than other vowel qualities – its formant values vary in kind.

In phonological terms, schwa has been characterized as a completely under-specified "featureless" vowel by some (e.g. **van Oostendorp 1995**), and as "weightless" (lacking a mora) by others (e.g. **Kager 1989**). According to van Oostendorp's approach, for example, Dutch schwa's featureless status may be (i) derived by feature loss, especially when a full vowel reduces to schwa under stresslessness, or (ii) derived by epenthesizing a completely underspecificied vowel. Finally, (iii) its featureless status may be lexical in origin. As discussed by **van Oostendorp (1995)**, Dutch possesses schwas of all three sorts.

Given its short duration and co-articulatory tendencies, schwa bears a phonetic similarity to the mere *audible release* of a consonantal constriction in the context of a following consonant. Indeed, certain epenthetic schwas may have their origin in consonantal release. Although such schwas may play an important functional role by providing acoustic cues to the first consonant in such consonant-consonant sequences, these schwas may, in fact, be "invisible" to the prosodic structure of the language, contributing neither to the syllable structure nor to the metrical structure of the system (**Hall 2006**).

Moreover, given its short duration and its consequent tendency to camouflage itself to its context through co-articulation, schwa may be confused with its absence, setting up a situation in which schwa–zero alternations may take hold in a system, for example, in Hindi (**Ohala 1983**).

This chapter is divided into three sections. First, I consider cases of schwa that have their origins in vowel reduction, taking Dutch (e.g. **van Oostendorp 1995**) and English (**Browman and Goldstein 1992**; **Flemming 2007**; **Flemming and Johnson 2007**) as case studies. Second, I consider cases of schwa that may have their origins in consonantal release, discussing **Hall's (2006)** findings and taking Indonesian (**Cohn 1989**) as a case study. Third, I consider two cases of synchronic schwa–zero alternation, one that unambiguously has its origins in (diachronic) schwa deletion (Hindi; **Ohala 1983**), and one that may be a case of (diachronic) schwa insertion (Chukchee; **Kenstowicz 1994**).

2 Reduction to schwa

Due to its short duration and its tendency to co-articulate, schwa is a likely outcome of vowel reduction in stressless domains.

2.1 Reduction to schwa in Dutch

Schwa in Dutch (**Nooteboom 1972**; **Kager 1989**; **van Oostendorp 1995**; among others) may be characterized as having three sources. **Van Oostendorp (1995)** calls these e-schwa (epenthetic schwa), r-schwa (reduction schwa), and u-schwa (underlying, i.e. non-alternating schwa). In (2) I provide his characterizations of these various schwas (**van Oostendorp 1995**: 100ff.).

(2) a. *Dutch e-schwa*
"Words ending in a consonant cluster (i.e. a closed syllable followed by a degenerate syllable) can get an optional schwa intervening between the two consonants [. . .] the variants without schwa of words like *melk* 'milk', *Marc* (name), *hulp* 'help', etc. sound overly formal to many native speakers."

b. *Dutch r-schwa*
"Stress-less vowels alternate with schwa in Dutch [. . .] However [. . .] [t]he restrictions are manifold. Some vowels never alternate at all, some positions in the word do not allow for reduction, etc. [. . .] [R]eduction is never obligatory."

c. *Dutch u-schwa*
"This is empirically a rest category. If a schwa is neither an r-schwa or an e-schwa, I call it an u-schwa, u for underlying. U-schwa does not alternate."

Our focus here is on r-schwa. **Kager (1989**: 303) establishes a "reduction hierarchy" of Dutch vowel qualities. In descending order of likelihood, Dutch vowels reduce to schwa thus: /e/ > /a/ > /o ø/ > /i/ > /u y/. Van Oostendorp points out that word frequency and sociolinguistic factors affect the likelihood of reduction to schwa as well (**chapter 79**: reduction; **chapter 90**: frequency effects). He further assumes that vocalic features are ideally licensed by stress; in the absence of stress, vocalic features are ideally unlicensed. As schwa is regarded as the "featureless" vowel – that is "a root node with no feature material dependent on it" (**1995**: 102) – then stressless syllables ideally possess schwa.

Interestingly, although u-schwa is found in word-final position [ˈmodə] 'fashion', [ˈtantə] 'aunt'), r-schwa is never found word-finally ([ˈtɔfe], *[ˈtɔfə] 'toffee', [ˈkola], *[ˈkolə] 'cola') or word-initially, for that matter ([e ˈlitə], *[əˈlitə] 'elite', [oˈval], *[əˈval] 'oval'). Van Oostendorp characterizes these peripherality restrictions with the theoretic devices of Optimality Theory (**Prince and Smolensky 2004**). Invoking "alignment" constraints, he proposes that prosodic edges and morphological edges must coincide, where "coincide" is defined as in (3).

(3) An edge E_1 of a category C_1 coincides with edge E_2 of category C_2 *iff* $E_1 = E_2$, and $\forall$ feature F_1 dominated by E_1 $\exists$ a feature F_2 dominated by E_2, such that $F_1 = F_2$ and $\forall$ F_2 dominated by E_2 $\exists$ F_1 dominated by E_1, such that $F_1 = F_2$.

Informally, "two edges coincide if they are exactly the same" (**1995**: 108). The basic idea is that peripheral reduction to schwa, as it is modeled as the elimination of all featural content, violates (3), since the phonological edge no longer coincides with the morphological edge. Crucially, word-final u-schwa (underlying, non-alternating schwa) does not violate alignment, "because the edge of the morphological word as well as the edge of the prosodic word will be schwa" (**1995**: 109). Regarding u-schwa's absence word-initially, van Oostendorp proposes that alignment constraints are stronger here in comparison to word-final position, noting that syllabification may cross stem–suffix boundaries, but not prefix–stem boundaries (**1995**: 132).

2.2 Reduction to schwa in English

Although it occurs exclusively in stressless contexts, English schwa, like Dutch, falls into three categories. First, some schwas are non-alternating (e.g. [ˈsoʊfə] *sofa*, [əˈbæʊt] *about*). Second, some schwas may be viewed as epenthetic, as in the syllabic allomorph of the past tense marker found after alveolars (e.g. [ˈbɹændəd] *branded*, [ˈtʰɛmtəd] *tempted*), or the syllabic allomorph of the plural/possessive/3rd singular marker found after sibilants ([ˈʤʌʤəz] *judges*, [ˈɹʌʃəz] *brushes*);some such schwas may vary toward [ɨ]. Third, some schwas alternate with full vowels in stressed contexts ([ɹəˈlæks] *relax* – [ˌɹilækˈseɪʃn̩] *relaxation*; [ˈæɾəm] *atom* –[əˈtʰamik] *atomic*). As in our discussion of Dutch, it is this third category that we consider. Also as in Dutch, there are frequency effects on the tendency to delete here (**Hooper 1978**; **chapter 79**: reduction; **chapter 90**: frequency effects).

Chomsky and Halle (1968: 110) write that “lax vowels reduce to a central, high, or mid unrounded ‘neutral’ vowel in English when they are sufficiently weakly stressed.” These authors characterize the distribution of schwa with the rewrite rule [−stress, −tense, V] → [ə]. The tensing of non-low vowels in prevocalic or word-final position is ordered before the schwa rule, thus accounting for the underlined vowels in, for example, [fi ˈjæskoʊ] *fiasco*, [ˈɛfiʤi] *effigy*, [ˈhindu] *Hindu*, [ˈænjuəɫ] *annual*, [ˈɹeidijeit] *radiate*.

Though “the exact phonetic realization of [ə] does not concern” Chomsky and Halle (1968: 110), the phonetic character of English schwa has been of interest to other researchers. Analyzing data from the Tokyo X-ray archive (Miller and Fujimura 1982), Browman and Goldstein (1992) report on the articulatory characteristics of schwa in the context [pV_1pəˈpV_2pə] for a single American English speaker, where V_1 and V_2 were all possible combinations of [i e a ɑ u]. As the production of labial consonants makes the fewest demands on tongue body posture, this context is likely to provide information about vowel-to-vowel articulation during the schwa, with negligible influence of the intervening consonantism.

On the one hand, if schwa is actually a “targetless” vowel – that is, if tongue posture during the production of schwa is solely a consequence of interpolating from the gesture(s) preceding schwa to the gesture(s) following schwa – then tongue activity during schwa should be fully predictable from the articulatory posture of these preceding and following contexts, provided these flanking postures are exhaustively quantified. On the other hand, if the production of schwa possesses components that are not fully predictable from its flanking contexts, then schwa may be considered to make independent demands on its own production. Note that such phonetic investigations may be of relevance to the formal phonological status of schwa. If schwa is phonetically “targetless,” this is consistent with its characterization as a phonologically unspecified vowel in the sense of van Oostendorp, for example. If, however, schwa has consistent phonetic properties regardless of context, this may be viewed as consistent with the formal characterization of schwa in which it is not completely “featureless.”

Browman and Goldstein report that the production of schwa for their speaker is highly variable, in ways that show a robust influence of flanking vocalism. The range of variation in the production of schwa is greater than the range of any other vowel, though this range does not encompass the entirety of the speaker's vowel space, and V_2 has more of a co-articulatory influence on schwa's production than does V_1 (which may be due to the fact that V_2 was stressed, whereas V_1 was stressless). Most important, schwa's production cannot be accurately characterized as a simple V-to-V interpolation:

> [I]t appears that the tongue position associated with medial schwa cannot be treated simply as an intermediate point on a direct tongue trajectory from V_1 to V_2. Instead, there is evidence that this V_1–V_2 trajectory is warped by an independent schwa component […] a warping of the trajectory toward an overall average or neutral tongue position. (1992: 41, 42)

Thus, the authors conclude that schwa is not genuinely targetless, but rather involves a tendency to gravitate toward the center of the vowel space as the tongue moves from preceding to following context.

In a study involving four American English speakers, Flemming (2007) also investigates the contextual variability of word-medial schwa (as in [səˈpʰoʊz] *suppose* or [ˈpɹabəbɫ] *probable*). His spectrographic analysis shows again that medial schwas are highly variable as a consequence of their context, especially in terms of their F2 properties, the articulatory correlates of which are tongue fronting/backing and lip posture. F1 varies as well – as a consequence of tongue height – but this variation is less pronounced than that found for F2. The limited variation of F1 may be attributable to the fact that flanking consonants necessarily involve a mouth closing/jaw-raising gesture, thus lowering F1.

Overall, Flemming suggests caution in concluding that schwa is completely targetless, even on the F2 dimension, since it is possible that the starting point and endpoint of the F2 trajectory through schwa – despite this trajectory's apparent targetlessness – are influenced by the intervening schwa itself.

Flemming proposes that English schwa's variability is rooted in its short duration. As a consequence of its short duration, vowel quality distinctions are reduced, perhaps to the point of being neutralized. Once neutralized, co-articulation may be engaged in with few limits, as there are no longer any lexical contrasts that might be maintained by inhibiting such co-articulatory tendencies (see especially **Öhman 1966** and **Manuel 1990, 1999** on the inhibitory role that lexical contrast may play in co-articulation).

Flemming proposes that the origin of American English schwa is rooted in speaker production, invoking the "target undershoot" proposals of **Liljencrants and Lindblom (1972)**. Still, the role of listener perception might be considered as well, since, as vowel duration decreases, the ability to discern quality distinctions is likely to decrease in kind (see, for example, **Ohala 1981**, **Labov 1994**, and **Silverman 2006**).

In sum, stresslessness feeds shortening, shortening feeds contrast loss, and contrast loss feeds co-articulation. Schwa results.

Flemming and Johnson (2007) find that, unlike word-medial schwa, schwa in word-final position (as in [ˈʧʰainə] *china* or [ˈkʰamə] *comma*) displays a relatively consistent mid-central quality, though a certain amount of between-speaker height variation is observed. It is suggested that, since word-final schwa – unlike medial schwa – is in contrast with other vowel qualities (unstressed /i/ and /oʊ/, for example [ˈbeɪɾə] *beta*, [ˈpɹiɾoʊ] *pretty*, [ˈmaɾoʊ] *motto*), it tends to be implemented in a more stable fashion so that contrasts here are reliably maintained. **Flemming (2007)** thus concludes that American English possesses two schwas: word-medial schwa, which is more variable, and word-final schwa, which is more stable.

Another possibility is that there is only one schwa in English, the variability of which is largely a consequence of its lexical context. Within-word motor routines are more frequently produced than are between-word motor routines. As such, they may be more susceptible to fixed co-articulatory effects than are between-word motor routines (see especially **Bybee 2001** on the relationship between frequency and co-articulation). Since the context that follows word-final schwa varies in unconstrained ways (depending only on the phonological shape of the following word), its co-articulatory tendencies may be less entrenched, less routinized, than its word-medial counterpart. Consequently, word-final schwa may not as readily possess fixed co-articulatory properties. The result is that word-final schwa may display more stability than its word-medial counterpart, which, in turn, increases the likelihood of schwa maintaining its contrastive status with other vowels here. Thus, whereas Flemming proposes that schwa is more stable in word-final position because it contrasts with other vowel qualities, schwa might instead contrast with more vowel qualities in word-final position because it is more stable.

3 Release into schwa

When lexical or morphological structure brings two consonants together (…C_1(+)C_2…), the identity of C_1 may, on occasion, fail to be successfully perceived by a listener. In the absence of consonantal release into a more open gesture – ideally, a vowel – cues that would otherwise be associated with the release of C_1 become jeopardized. Such cues include offset formant transitions and plosive burst frequencies associated with oral place of articulation, and the noise, pop, or low-frequency cues associated with aspiration, ejectivity, or voicing, respectively. In many languages, the loss of such cues sets the stage for merger or neutralization, such that C_1 loses its contrastive oral configuration, its contrastive laryngeal setting, or perhaps both (e.g. **Lombardi 1991**; **Steriade 1997**).

However, a very different diachronic route is taken in many other languages: in the context…C_1(+)C_2…, C_1 is released into an excrescent vowel before the C_2 constriction is fully achieved, where "excrescent" refers to a particularly short interval of the speech stream that may be an artefactual consequence of repositioning the articulators as they move from one posture to another. Upon the release of C_1, the aforementioned cues that crucially rely on this segment of the speech stream are much more likely to be saliently encoded in the speech signal, and hence C_1 tends to be more resistant to neutralization or merger.

Phonetically speaking, if we assume that the survival of these C_1 cues is dependent in great part upon C_1 release, then this release is likely to become exaggerated over time, culminating in schwa: $C_1əC_2$. Schwa is short in duration, is subject to significant contextual co-articulation, and is consequently auditorily rather similar to the excrescent vowel of mere release. **Hall (2006)**, for example, finds that inserted schwa and other so-called "intrusive" vowels – vowels that may have their origin in excrescence, but come to bear phonetic similarity to full-fledged vocalism – are more often encountered between heterorganic consonants, as opposed to homorganic consonants (see also **chapter 67**: vowel epenthesis). This is not an unexpected result: C_1C_2 homorganicity decreases the likelihood of C_1 release, since the articulators are likely to maintain their positions as C_1 is followed by C_2 in such homorganic clusters; employing **Goldsmith's (1976)** autosegmental notation, this tendency has been characterized in terms of "geminate integrity" (**Hayes 1986**; **Schein and Steriade 1986**). By contrast, C_1C_2 heterorganicity increases the likelihood of C_1 release, since the articulators necessarily change their posture as C_1 is followed by C_2, and thus C_1 is more likely to be audibly released. More importantly, in homorganic clusters, there is less functional motivation for C_1 to be released, since its place cues may be "read off" the release cues of C_2. The C_1 of heterorganic clusters enjoy no such functional benefit, however, and thus C_1's release here plays a more important functional role.

Once schwa comes into being due to consonantal release, several further developments are possible. First, this schwa may (or may not) be subject to an assimilatory influence from neighboring consonants and/or vowels. **Hall (2006)** observes that intrusive vowels often bear the mark of neighboring vowels, especially when a sonorant – as opposed to an obstruent – intervenes, often consisting of a full copy of the trans-sonorant vowel. Trans-sonorant harmony is not completely unexpected, since vowel quality cues in the form of formant values may be present during sonorant consonants, and thus might more readily "bleed" into a neighboring vowel. Such "bleeding" is largely absent through obstruent constrictions, due to the significant attenuation (or absence) of resonance energy during their implementation.

Hall further finds that such intrusive vowels – be they schwa or vowel copies – are often ignored by prosodic phonology, in that they are "skipped over" for stress. Hall distinguishes such intrusive vowels from those that are genuinely epenthetic; vowels that are not invisible to prosodic structure. (See also **Levin 1987** on excrescent *vs.* genuinely epenthetic vowels.)

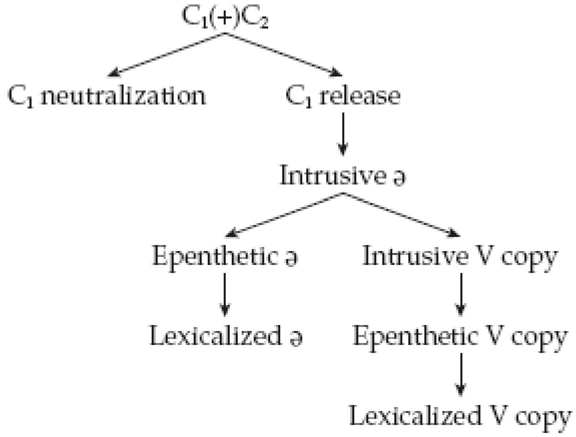
The language data in (4) are excerpted and adapted from **Hall (2006)**. In (4a) are languages that Hall reports to possess intrusive schwa; those in (4b) possess harmonically determined intrusive vocalism. In these cases, the exemplified (underlined) intrusive vowels behave as if "invisible" to prosodic structure. Finally, in (4c) are cases in which epenthetic vowels are "visible" with respect to prosodic structure, and which may have diachronically originated as intrusive vowels. Such vowels, then, may have their diachronic origins in C_1 release.

(4) a.	*Release into schwa*		
	Bulgarian	garəbav	'hunchbacked'
	Dutch	kaləm	'quiet'
	English (dialects)	arəm	'arm'
	German (S. Hamburg)	baʁatən	'to fry'
	Saami	skuolːəɦiː	'owl'
	Sanskrit	darəʃata	*no gloss*
b.	*Release into a vowel copy*		
	Arbore	leɦ+e+t+atto	'that ewe'
	Chamicuro	tuʔulu	'chest'
	Finnish	kalavo	'transparency'
	Hausa	kʷurukʷuːtu	'small drum'
	Hocank (Winnebago)	sĩnĩ	'cold'
		hoːʧəgə+rə	'the Hocank'
	Hua	okuruma?	'sky'
	Kekchi	paʔat	'twins'
	Lakhota	gala	*no gloss*
	Mamainde	mih+i+takʔu	'it is cloudy'
	Mono	gàfūrū	'mortar'
	Popoluca	itaʔa	'your father'
	Scots Gaelic	ʃałak	'hunting'
	Spanish (Chilean)	koronika	'chronicle'
	Tiberian Hebrew	ʃalaħ+a+t	'you (FEM SG) sent'
c.	*Prosodically "visible" epenthesized vowels*		
	Irish Gaelic	ˈagələ	'fear'
		ˈgorəm	'blue'
	Late Latin	skiriptum	'a writing'
	Negev Bedouin Arabic	gaˈhawa	'coffee'
	Oscan	múlúkiːs	'name'
		paterei	'father'
	Sardinian	umbara	'shadow'

Considering the dialectal and diachronic behavior of intrusive vowels, Hall notes that, for example, while Argyllshire Gaelic possesses intrusive schwa, Outer Hebrides dialects possess vowel copies. As exemplified in (4c), the intrusive vowel may develop into a full-fledged vowel, in the sense that it comes to be fully incorporated into the prosodic phonology of the language. Languages as diverse as Irish Gaelic, Late Latin, Negev Bedouin Arabic, Oscan, and Sardinian seem to have evolved in this fashion. Finally, the intrusive vowel may ultimately lexicalize, in the sense that it becomes a non-alternating component of morphemic structure, such as in southern and western dialects of Dutch.

The flowchart in (5) summarizes the various routes that $C_1(+)C_2$ patterns might take; a pattern might stabilize at any point in its development.

(5) *Diachronic routes of* $C_1(+)C_2$



It is not possible to accurately predict which diachronic route a given language will take. However, upon careful consideration of certain phonetic and functional pressures on the diachrony of linguistic sound systems, cross-linguistic tendencies are likely to emerge. If neutralization of C_1 does not induce excessive homophony, a language might be more able to tolerate this neutralization due to C_1 "unrelease." However, if a language were to suffer excessive homophony as a consequence of C_1 neutralization, then it might more likely possess C_1 "release," which might diachronically culminate in schwa or a vowel copy that may or may not be prosodically "invisible" (**Martinet 1952**; **Hoenigswald 1960**).

Indonesian is a language that seems to possess an "intrusive" schwa in the sense of Hall. As reported by **Cohn (1989)**, monomorphemic Indonesian words possess right-to-left syllabic trochees, end-rule right, with initial dactyls in words with an odd number of syllables, excluding three- and (by necessity) one-syllable words. However, schwas are completely invisible to stress. Examples presented in (6) (**Cohn 1989**: 174) include both native Indonesian words and assimilated loans. Whether the loans should be characterized as possessing genuinely epenthetic schwa, or perhaps instead involve underlying schwa, remains an open question for now (see especially **Silverman 1992** for proposals regarding the interpretation of apparently epenthetic vowels in loan phonology).

(6)	*All full vowels*	*Schwas and full vowels*		
a.	'σσ	ə'σ	bə'ri	'give'
			kər'ja	'work'
b.	σ'σσ	əə'σ	sətə'lah	'after'
c.		σə'σ	'gamələn	'Indonesian orchestra'
d.	ˌσσ'σσ	σ'σəσ	a'partəmen	'apartment'
e.		ə'σəσ	ʧə'ritəra	'story'
f.		əə'σσ	pərəm'puan	'woman'
g.		σə'σσ	kopə'rasi	'cooperation'
h.	ˌσσˌσσ'σσ	ˌσəσσ'σσ	ˌdifərensi'asi	'differentiation'
			ˌdivərsifi'kasi	'diversification'

Significantly, Cohn reports that the distribution of schwa is largely predictable, and may thus be viewed as a consequence of epenthesis. In the parlance of Hall, Indonesian schwa is intrusive in nature: it is invisible to stress, and its presence is largely predictable. Note in particular that almost all schwas in (6) are found between heterorganic consonants, at least one of which is a sonorant.

Given its apparent predictability, the origin of Indonesian schwa might indeed lie in consonantal release into an excrescent vowel.

4 Schwa–zero alternations

As noted, schwa is typically short in duration, is subject to significant co-articulation, and, correspondingly, possesses few acoustic features that render it auditorily distinct from its surrounding context. As a consequence of schwa's auditory indistinctness, its *presence* in a given phonetic context may be susceptible to confusion with its *absence* in an otherwise identical phonetic context. When two or more auditory events are confusable with each other, a condition is set up that may lead to diachronic change. One plausible outcome of this particular situation may be the introduction of schwa–zero alternations: in certain acoustic contexts and/or under certain functional conditions schwa may diachronically survive, while in other acoustic contexts and/or under other functional conditions schwa may disappear. The question is: in what situations is the schwa likely to survive, and in what situations is the schwa likely to be lost?

4.1 Schwa–zero alternation in Hindi

The Hindi schwa–zero alternation is discussed extensively by **Ohala (1983)**. Consider the forms in (7) (excerpted and modified from her tables 6.1 and 6.3). According to **Ohala (1999)**, the vowel in alternation with zero is actually slightly lower than schwa: [a]. It is transcribed [ə] in **Ohala (1983)**, and herein as well, for the sake of internal consistency. Schwas that alternate and/or vary with zero are underlined.

(7)	a.	pitʃka	‘squeezed’	pitʃə̲k	‘squeeze’
		pɪgʰla	‘melted’	pɪgʰə̲l	‘melt’
		dewrani	‘brother-in-law’s wife’	dewə̲r	‘brother-in-law’
		nəmkin	‘salty’	nəmə̲k	‘salt’
		sɪski	‘a sob’	sɪsə̲k	‘sob’
		hɪrni	‘doe’	hɪrə̲n	‘deer’
		təɽpa	‘cause to be restless’	təɽə̲p	‘restlessness’
		wapsi	‘on return’	wapə̲s	‘return’
		upri	‘pertaining to the top’	upə̲r	‘top’
		ʊbʈən	‘an unguent’	ʊbə̲ʈna	‘to anoint’
		gərdʒila	‘thunderous’	gərə̲dʒna	‘to thunder’
	b.	a+səməj	asəməj	‘inopportune’	
		ə+ʃərir	əʃərir	‘without body’	
		ə+kələŋk	əkələŋk	‘spotless’	
		kʊ+ʃəkʊn	kʊʃəkʊn	‘bad omen’	

The generalization is that schwa alternates with zero in would-be VCəCV contexts (7a), provided that it is not the first vowel of the morpheme (7b). Ohala's synchronic characterization of this alternation is expressed with the linear rewrite rule conventions of **Chomsky and Halle (1968**: 121): “ə → Ø / VC___CV. *Condition:* There may be no morpheme boundary to the left of the /ə/.”

The first question to ask is whether the schwa–zero alternation in Hindi is a reflex of historic schwa *insertion* or historic schwa *deletion*. Fortunately, the historical record is very clear on this matter. Hindi schwa derives from Sanskrit [ə] and short [a]. In Old Hindi, this vowel, and some instances of other short vowels ([i] and [ʊ]), alternated with zero in VCVCV: contexts (**Misra 1967**).

The route from short [a] to the schwa–zero alternation found today may be related to the fact that contrastively short low vowels, due exactly to their contrastively short duration, are quite likely to gradually rise: as a consequence of their attendant jaw lowering, it takes longer to implement low vowels than non-low vowels, and so *contrastively* short low vowels are thus especially susceptible to rising. Upon rising, they become more schwa–like, and are thus susceptible to confusion with their absence in certain contexts. One such context is VCəCV. Provided that phonetic confusion between VCØCV and pre-existing VCCV sequences does not induce undue semantic confusion (by inducing a significant amount of homophony), it is quite possible that the sound pattern may ultimately change from VCəCV to VCCV. This is the Hindi pattern.

Schwa is susceptible to confusion with its absence in many other acoustic contexts as well, such as when it finds itself flanked by more than one consonant on one side, for example VCCəCV and VCəCCV. Nonetheless, schwa usually does not delete in such contexts in Hindi. This may be related to the further possibility of medial C loss here. Were schwa to delete in a VCCəCV or VCəCCV context, the medial consonant might suffer a significant cue loss, as it would lack both approach cues and release cues. Thus, were VCCəCV or VCəCCV to become VCCCV, the sequence might be confused with VCCV. That is, the loss of schwa in these contexts may lead to a percept involving only two – not three – consonants. At this point, the chances of inducing homophony – hence confusion on the part of listeners – increase considerably, since in theory these lost medial consonants may possess many different values, and thus many words may rely on them to maintain their acoustic distinctness. Since speech signals that confuse listeners (as opposed to those that do not confuse listeners) are less likely to be reproduced as these listeners become speakers, the presence of confusing signals as part of the conventionalized speech repertoire may be passively curtailed (**Martinet 1952**; **Labov 1994**; **Silverman 2006**). This may have influenced the present-day Hindi pattern: VCCəCV and VCəCCV do not alternate with VCCV.

There are, however, patterned exceptions to the absence of schwa deletion in VCCəCV and VCəCCV contexts. Consider the forms in (8) (excerpted and modified from **Ohala's (1983)** table 6.6; underlined schwas vary with their absence).

(8)	kad̪əmbri ~ kad̪əmbə̲ri	'a novel, name for a girl'
	ust̪ra ~ ust̪ə̲ra	'razor'
	puɳɖrik ~ puɳɖə̲rik	'white lotus'
	məɲʤri ~ məɲʤə̲ri	'tiny cluster of flowers, name for a girl'

Hindi possesses variable schwa deletion in these forms, and thus indeed possesses sequences of three consonants that are a consequence of schwa loss. As stated, however, these exceptions are patterned, for as Ohala observes, schwa deletion here results in triconsonantal sequences that are also found elsewhere, and are usually of the form nasal–homorganic stop–sonorant. The development of schwa deletion in such forms is thus not completely unexpected: the phonetic properties of these particular triconsonantal sequences are readily recoverable from the speech signal, since the medial consonant here does not possess place features that are distinct from the preceding nasal, and thus it does not contribute place cues of its own. Consequently, not only are such sequences more likely to be found elsewhere, but also – and perhaps even as a partial consequence of their presence elsewhere – such sequences may more readily enter the language via developments such as schwa deletion. Indeed, as Ohala notes, "[T]hree-consonant clusters in native words are rather few, and in general, most two- and three-consonant clusters that we find at the phonetic level […] occur due to the ə-deletion rule" (1983: 135).

4.2 Schwa–zero alternation in Chukchee

Another case of schwa–zero alternation is reportedly found in Chukchee. According to **Kenstowicz (1994)**, Chukchee possesses a synchronic process of schwa insertion under varying phonological and morphological conditions. Consider the forms in (9). In (9a) the schwa precedes the morpheme boundary; in (9b) it follows. (Data are from **Skorik 1961**, excerpted and modified from Kenstowicz's (8); ostensibly inserted schwas are underlined; allomorphs unambiguously lacking schwa are not consistently provided by Kenstowicz.)

(9) a. CCə+C

tumɣə+ret	'group of comrades'
memlə+jocɣ+ən	'pail'
qejŋə+ɣiniw	'lots of brown bears'

b. C+əCC

watap+ənlaŋ	'place without moss'
rʔew+ətʔul	'whale meat'
nəm+ətku+n	'group of villages'

When a morpheme boundary is present in a string of three adjacent consonants (C+CC or CC+C), schwa is found at the morpheme boundary itself (CəCC or CCəC), and thus "morpheme integrity" is preserved. Employing Optimality Theory formalism (**Prince and Smolensky 2004**), Kenstowicz restates schwa's behavior in terms of the notion "contiguity": "If two segments /x/ and /y/ are adjacent in the lexical representation of a morpheme, then representations in which the exponents of /x/ and /y/ are separated by extraneous segments in prosodic structure are nonoptimal." However, in contexts where segmental material would otherwise be unsyllabified and hence deleted (as in the case of the C in Chukchee CCC sequences), epenthesis may be necessary so that another constraint, "parse" ("avoid unsyllabified segments"), may be abided by. In short, "Don't insert, and don't delete. But if you must insert in order to realize contrastive material, do it at a morpheme boundary."

Kenstowicz suggests that the location of Chukchee schwa may be functionally motivated, writing, "The Contiguity constraint may have some parsing motivation, preferring candidates in which the input is realized as a substring of the output, or vice versa." However, he does not suggest a reason why this stated substring relationship might be an aid to parsing.

Indeed, in terms of parsing, schwa is serving a demarcative function here, in that it provides information about morphological structure (indirectly encoded in "contiguity"): the presence of schwa cues morpheme boundaries. Schwa in Chukchee may thus be characterized as a "boundary signal" (**Trubetzkoy 1939**) or "prosody" (**Firth 1948**), a component of the speech stream that serves a syntagmatic/demarcative function.

As Kenstowicz observes, however, the behavior of schwa in Chukchee is somewhat more complicated. Consider the forms in (10) (excerpted and modified from Kenstowicz's (10); relevant allomorphs reportedly possessing epenthetic schwa are underlined; stops nasalize before nasals).

(10) a. #CəC

pəne+k	'to grind'	ɣe+mne+lin	past tense
təm+ək	'to kill'	ɣe+nmə+len	
tənut+ək	'to swell'	ɣe+nnut+lin	

b. CəC#

qepəl	'ball'	qepl+e	(ERG)
miməl	'water'	meml+aratɣaɣən	'waterfall'

In the forms in (10), the relevant schwas are not found at morpheme edges. Instead, when a morpheme boundary is co-extensive with a word boundary, schwa is found *away* from that boundary. Since word-edge consonants may run the risk of unrecoverability when lexically adjacent to a consonant that is unable to saliently encode release cues ($\#C_1C_2\ldots,\ldots C_1C_2\#$), such would-be "faithful" speech tokens may be confusable with minimal pairs lacking the edgemost consonant ($\#C_2\ldots\ C_1\#$). Again, on the assumption that less confusing speech tokens are more likely to become the conventionalized norm than are more confusing speech tokens, then those tokens that do indeed possess releases (ultimately into schwas) are more likely to be successfully recovered by listeners, and hence are more likely to be conventionalized as the speech norm ($\#C_1əC_2\ \ldots,\ \ldots\ C_1əC_2\#$).

Kenstowicz characterizes this word-boundary effect by proposing that, in Chukchee, maintaining contrastive material in its word-edge position is more important than maintaining morpheme-internal contiguity. This is characterized by an "alignment" constraint (see e.g. **McCarthy 2002**). Kenstowicz notes:

> The alignment constraint may also have functional motivation as a parsing strategy indicating that the first segment of the word is more salient and functions as its signature. If parsing proceeds from an initial recovery of the syllables […] then lexical access is presumably faster if the first element of the prosodic category is also the first element in the lexical representation.

The *absence* of schwas at word edges may thus also be viewed in terms of boundary signals or prosodies: exactly because word-medial schwas may signal a morpheme boundary, hypothetical word-edge schwas might, on occasion, serve to render between-word boundaries confusable with within-word boundaries. Instead, word boundaries might be cued in part by low-probability consonantal sequences that – due in great part to the prevalence of word-medial schwas – are less often encountered word-medially. That is, preserving consonants at word edges, as opposed to inserting schwa here, might render word boundaries more prominent due to the potentially low probability of such boundary-straddling (hence boundary-*cueing*) sound sequences.

In functional terms then, the observed placement of schwa in Chukchee may have evolved in service to two functions. First, it salvages the place cues of consonants that might otherwise be subject to perceptual confusion or loss (indirectly encoded in "parse"). Second, schwa's presence word-medially serves as a cue to morpheme boundaries (indirectly encoded in "contiguity"), while its absence at word edges serves as a cue to word boundaries (indirectly encoded in "align").

5 Concluding remarks

In this chapter we have considered some of the unique properties of schwa.

Schwa is short in duration, is subject to significant co-articulatory variation, and tends to gravitate toward the center of the vowel space. Phonologically, it has been classified as a "featureless" vowel by some, and as a "weightless" vowel by others. Its featureless status makes it a likely candidate for epenthesis. Also, reduction to schwa may be modeled as the deletion of all vowel features.

Schwa is often the result of vowel reduction. Its short duration and its consequent tendency to co-articulate make schwa a likely candidate for the vocalism of stressless domains.

Some schwas may have their origins in the audible release of a consonant, when this consonant is immediately followed by another consonant: cues to the phonetic content of consonants are more reliably communicated upon their audible release, ideally into a vowel. These schwas may or may not be visible to the prosodic structure of the language.

Perhaps as a consequence of its tendency to camouflage itself, schwa is especially susceptible to deletion, and thus may alternate with zero under varying conditions.

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