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8. Sonorants

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Sections

1 Introduction

The class of sonorants includes vowels, semi-vowels, liquids, and nasals, with the sonorant consonants sometimes being referred to as "resonants" (e.g. **Laver 1994**). There is abundant cross-linguistic evidence for natural class behavior of these segments. For example, in languages where consonants can be syllabic, the class of syllabic segments is almost always restricted to sonorants (Imdlawn Tashlhiyt Berber is an exception; see **Dell and Elmedlaoui 2002**). Further, there are quantity-sensitive languages in which the set of weight-bearing segments is restricted to sonorants, or to a subset thereof (see **Zec 2007** and **CHAPTER 57**: QUANTITY-SENSITIVITY for examples). Similarly, in languages where consonants can support tone contrasts, the consonants involved are almost always sonorant (e.g. **Yip 2002**). In addition, in languages which permit complex onsets, the second element is typically restricted to a sonorant consonant (disregarding SC clusters). Taken together, these observations suggest a distinctive feature, e.g. [sonorant], which distinguishes sonorants from obstruents (i.e. plosives and fricatives). These examples further suggest that the most straightforward evidence for the class behavior of sonorants comes from their patterning with respect to suprasegmental aspects such as syllable structure, moraic structure, and tone – an observation to which we return in §3.

While the class of sonorants is well established, there are a number of issues relating to sonorants which are a matter of debate. This chapter focuses on three such issues:

(i) How should sonorancy be represented in a theory of segmental structure? (§2)

(ii) How should less straightforward cases of sonorant class behavior be accounted for, in particular those cases in which voiced stops and voiced fricatives display sonorant-like behavior? (§3)

(iii) How should sonorancy be defined phonetically? (§4)

On closer inspection, each of these issues pertains to the relation between sonorancy and voicing. Any approach to sonorancy must do justice to the observation that voicing in sonorants is never contrastive (see §2.3), but may nevertheless be phonologically active. §2 considers a range of proposals that have been advanced to account for this observation, and also provides a more general discussion of laryngeal modifications in sonorants. The relation between sonorancy and voicing is also relevant in the class behavior of sonorants and voiced stops and fricatives, which is considered in §3. §4 reviews a number of possible phonetic correlates of sonorancy. It will be suggested that sonorants are best characterized acoustically, in terms of a clearly marked formant structure – a position that is perhaps most closely identified with the work of Ladefoged (e.g. 1971, 1982, 1997). It will also be suggested, somewhat more tentatively, that the class behavior of sonorants and voiced obstruents is phonetically natural to the extent that both are voiced, with the latter involving "active voice facilitation," although there is some reason to believe that aerodynamic correlates may also be relevant.

In what follows, my concern will be with the class of sonorants as a whole. Thus I will have little to say about the specific properties of sub-types of sonorants, some of which are discussed in other contributions (e.g. CHAPTER 15: GLIDES; CHAPTER 30: THE REPRESENTATION OF RHOTICS; CHAPTER 31: LATERAL CONSONANTS), or about the relation between sonorancy and syllable structure (for this, see e.g. CHAPTER 33: SYLLABLE-INTERNAL STRUCTURE; CHAPTER 49: SONORITY; CHAPTER 53: SYLLABLE CONTACT).

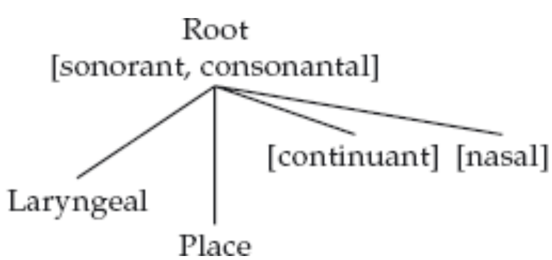
2 How should sonorancy be represented in a theory of segmental structure?

2.1 Representations of sonorancy

Different proposals have been made regarding the formalization of sonorancy in phonological theory. The mainstream view, as espoused in Chomsky and Halle (1968; *SPE*) and subsequent work in Feature Geometry (e.g. Clements 1985; Sagey 1986; McCarthy 1988; Clements and Hume 1995; Halle *et al.* 2000), recognizes a major class feature [sonorant]. An alternative proposal within Feature Geometry is the "SV hypothesis," in which [sonorant] is replaced by a "Spontaneous Voicing" or "Sonorant Voice" node (e.g. Rice and Avery 1989, 1991; Piggott 1992, 1993; Rice 1993; Avery 1996). A quite different approach is taken in Dependency Phonology and related frameworks such as Radical CV Phonology, where sonorancy is viewed as a particular manifestation of a vocalic "component" or "element," e.g. |V| (Anderson and Ewen 1987; van der Hulst 1995) or |L| (Botma 2004; Botma and Smith 2006, 2007). However, while these frameworks assume different "atoms" of representation, they share important insights with both *SPE* and Feature Geometry, as we will see below. Finally, some approaches, e.g. most versions of Element Theory (see Harris and Lindsey 1995; Harris 1996), do not recognize a feature or "element" representing sonorancy. This section considers each of these approaches in some detail.

In *SPE*, [sonorant] is assumed to be a "major class feature," together with [consonantal] and [continuant]. What sets major class features apart from other features is that the former are not bound to any particular articulator. Thus, as Kenstowicz (1994: 36) puts it, [sonorant] specifies "phonologically relevant degrees of constriction imposed by essentially any articulator." However, since segments in *SPE* consist of unordered feature bundles, major class features do not have any independent theoretical status.

In subsequent work in Feature Geometry, where features are hierarchically organized, it is usually assumed that [sonorant], together with [consonantal], forms part of the root node, from where it dominates other features and class nodes, e.g. the Laryngeal node and the Place node. Consider for example the geometry of McCarthy (1988: 105), with irrelevant details omitted (see also CHAPTER 27: THE ORGANIZATION OF FEATURES):

(1)


McCarthy (1988: 97) observes that major class features do not display the kind of behavior that is typical of other features:

> [sonorant] and [consonantal] differ from all other features in one important respect: they arguably never spread, delink, or exhibit OCP effects independently of all other features. Expressed somewhat differently, this means that the major class features do not assimilate, reduce, or dissimilate except in conjunction with processes that affect the entire segment. Therefore the major class features should not be represented on separate tiers as dependents of the Root node … Instead, [they] should literally form the Root node, so that the Root node ceases to be a class node and instead becomes a feature bundle itself.

The notion of major class features is not uncontroversial. From the point of view of classification, the binary features [sonorant] and [consonantal] define three classes (vowels, resonants, and obstruents), but the combination [−consonantal, −sonorant] is problematic. In addition, as Harris (1996) notes, the contrastive load of major class features is generally low: [sonorant] and [consonantal] rarely express contrasts which are not also expressed by other features, such as [nasal] and [continuant]. Harris (1996: 312) further notes that the presence of major class features in the root node clutters up the statement of phonological processes, specifically those involving lenition:

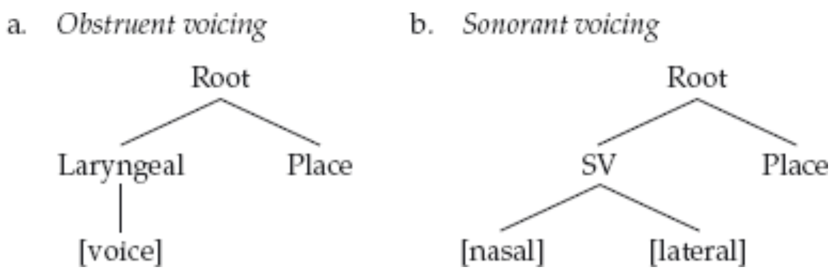
> The primary effect [of lenition] is to delink place (as in debuccalization) or [−continuant] (as in vocalization

and spirantization). In the aftermath of both operations, some mopping up has to be done, including adjustments to the major-class affiliation of the affected segments. Vocalization of an oral stop (as in *p* → *w*), for example, calls not only for the rewriting of [−continuant] as plus but also for switches in [consonantal] and [sonorant].

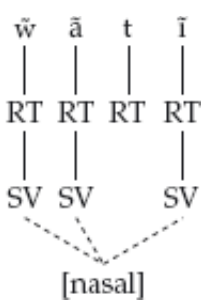
In Harris's analysis, lenition is instead accounted for in terms of a reduction in complexity of the affected segment. However, it would seem that such an analysis is at odds not only with the feature [sonorant], but also with [voice] (or its elemental equivalent), whose contrastive status is firmly established. It is difficult to see how a process of intervocalic voicing (e.g. *p* → *b* / V __ V) can be interpreted as involving feature reduction, unless it is assumed that the voicing of the output already inheres in the lenition target. This option is not considered in **Harris (1996)**, though it is perhaps compatible with Harris's more recent approach to sonority (see **Harris 2006**).

Harris goes on to make a compelling case for rejecting [consonantal], noting in passing that there are few processes in which major class features function as the target or trigger of phonological processes. However, it is questionable whether this last point can be maintained for the feature [sonorant], not just in light of the examples of sonorant class behavior mentioned in §1, but also in view of the kind of arguments advanced by proponents of the SV hypothesis.

The SV hypothesis can be regarded as an attempt to accord [sonorant] the same status as other, non-major class features. The key insight of this approach is that there are two types of phonological voicing: one realized through a laryngeal feature ([voice], dominated by the Laryngeal node) and a property of obstruents (2a), and one through SV ("Spontaneous Voice" or "Sonorant Voice") and a property of sonorants (2b).

(2)


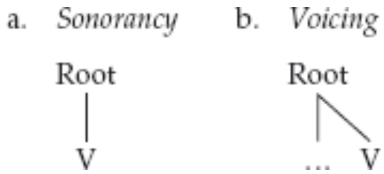
The SV node organizes sonorant features such as [nasal] and [lateral], and acts as both a trigger and a target for autosegmental processes such as spreading and delinking. For example, **Piggott (1992)** accounts for the nasal harmony pattern of Southern Barasano (discussed in more detail in §3) on the assumption that all targets are specified for SV, which provides a landing site for a harmonic feature [nasal]. Thus a form like [w̃ãtĩ] 'devil' involves association of [nasal] to all SV-specified segments in the word:

(3)


Spreading of the SV node itself is assumed to take place in sonorant-induced voicing phenomena, such as post-nasal voicing assimilation (see §2.2).

The function of the SV node is similar to class nodes such as Laryngeal and Place, in that it designates functional feature groupings (see especially **Piggott 1993** for an elaboration of this idea). In addition, some phonologists have argued that the unmarked dependent of the SV node is the feature [nasal], which captures the observation that nasals are the unmarked type of sonorant consonants. According to this view, nasals are underlyingly specified for SV only, with their nasal aspect supplied by a default rule which fills in [nasal] (e.g. **Rice and Avery 1991**; **Rice 1993**). However, this assumption seems difficult to combine with an account of post-nasal voicing assimilation in terms of SV spreading (see §2.2).

A difference between class nodes and the SV node is that the latter is construed as having phonetic content. This assumption is not unproblematic. While a distinction between sonorant voicing and obstruent voicing seems well motivated on phonological grounds, the question whether there is phonetic support for this distinction is rather more contentious (see §4.1 for further discussion). To this extent at least, a more promising approach is taken in Dependency Phonology and related frameworks, where sonorancy and voicing are viewed as manifestations of a single component, whose interpretation depends on its position in the phonological structure. For example, van der **Hulst (1995)** represents sonorancy in terms of a |V| in the “head” component of a segment (4a) and voicing in terms of a |V| in the “dependent” component (4b). (The possibility of expressing the relative prominence of voicing can also be used to represent the difference between sonorants and sonorant-like obstruents, as we will see in §3.)

(4)


Van der Hulst further assumes that in (4b) the head may be either an obstruent, i.e. |C|, or a sonorant, i.e. |V|. The latter assumption attempts to do justice to the observation that there are languages in which sonorants trigger voicing. Such processes cannot involve the head |V|, given van der **Hulst's (1995**: 96) assumption that “dependent properties can spread independently, while heads can only spread together with their dependents.” This makes head components similar to major class features, while the possibility of “active” voicing in sonorants is reminiscent of the SV hypothesis.

2.2 The relationship between sonorancy and voicing

Phonetically, the natural state of sonorants is to be voiced. Phonologically, this is reflected by the observation that voicing in sonorants is unmarked. Inspection of the UPSID database (**Maddieson 1984**) reveals that most languages have voiced sonorants only (96.6 percent) and that the presence of non-voiced sonorants in a language implies the presence of voiced ones. Furthermore, voicing in sonorants is often redundant. This has been interpreted to mean that [voice] is underspecified for segments specified as [sonorant] and supplied by default in the post-lexical phonology (e.g. **Kiparsky 1985**; **Archangeli 1988**; **Lombardi 1994**; **Steriade 1995**).

One phenomenon which suggests that sonorants are underlyingly unmarked for voice is Japanese Rendaku (e.g. **Itô and Mester 1986**; **Itô *et al.* 1995**; **Nasukawa 2005**). This concerns a voicing process which targets an initial voiceless consonant of the second member of a compound, converting it into its voiced counterpart, as in /onna + kokoro/ → [onna gokoro] ‘woman's heart’. Rendaku interacts with a constraint known as Lyman's Law, which bans multiple occurrences of voiced obstruents in morphemes (at least, in those morphemes which belong to the “Yamato” stratum of the lexicon). Lyman's Law blocks Rendaku in those cases where a morpheme already contains a voiced obstruent, as in /kami + kaze/ → * [kami gaze] ‘divine wind’. Rendaku is not blocked if the morpheme contains a nasal consonant, as in /ori + kami/ → [ori gami] ‘paper folding’, suggesting that nasals are not specified for voice. However, a further complication is that nasals in Japanese do trigger post-nasal voicing assimilation, as in /kam + te/ → [kande] ‘chew-GER’. This leads Itô and Mester to argue that nasals are under-lyingly underspecified for [voice], which is filled in at a stage in the derivation after Rendaku has applied, but before affixation applies.

Rice (1993) observes that such an approach is complicated by the observation that there are languages in which sonorant voicing is active in derived environments only. An example is the Puyo-Pongo dialect of Quechua, which displays post-nasal voicing of suffix-initial stops (5a), but contrasts post-nasal voiceless and voiced stops within morphemes (5b) (cf. **Rice 1993**: 315):

(5)	a.	[wasi-ta]	‘house-OBJ’	[wakin-da]	‘others-OBJ’
		[sinik-pa]	‘porcupine-GEN’	[kam-ba]	‘you-GEN’
	b.	[ʃinki]	‘soot’	[ʧunga]	‘ten’
		[tsuntsu]	‘ragged’	[pundzu]	‘fuzzy’

A theory in which [voice] is supplied to sonorants post-lexically cannot account for these facts, since at this point in the derivation the forms in (5a) and (5b) can no longer be distinguished. Rice argues that the Quechua facts can be accounted for by the SV approach on the assumption that (i) nasals are underlyingly represented for SV (with [nasal] being underspecified), and (ii) that SV spreads to a following stop in derived environments. This scenario is illustrated in (6), where N denotes a nasal and C a suffix-initial stop:

(6)


However, it would seem that this approach is not without problems either, since it is unclear how SV spreading can be combined with specification of the SV dependent [nasal]. Regardless of where in the derivation [nasal] is filled in, we would expect the phonetic result of post-nasal voicing in (6) to be a nasal, not a voiced oral stop. But in any case, voicing phenomena such as those in Quechua suggest that voicing in sonorants is not always redundant, but must sometimes be part of the phonological specification of these sounds.

In most versions of Feature Geometry, the features [voice], [spread glottis], and [constricted glottis], which specify voiced, aspirated, and glottalized sounds respectively, are grouped together under the Laryngeal node. However, there is reason to believe that these features entertain different relationships with sonorancy, which cannot be captured without additional stipulation.

As noted in §2.2, languages differ as to whether voicing is phonologically active in sonorants. In traditional feature theory, the question is therefore not so much whether sonorants can be specified for [voice], but rather at which stage in the derivation this specification takes place. In the SV approach, on the other hand, sonorants are incompatible with [voice], though this must presumably be stipulated in the form of a co-occurrence constraint, given that SV can combine with other dependents of the Laryngeal node, such as [constricted glottis] (in languages with glottalized sonorants, such as Sedang and Klamath).

A number of researchers have rejected a phonological category of voiceless sonorants, i.e. sonorants specified for [−voice] (e.g. **Halle and Stevens 1971**; **Ewen 1980**; **Anderson and Ewen 1987**; **Lombardi 1994**; **Botma 2005**). There are a number of reasons for this. One is that such an account would rely on a binary-valued feature [voice], which among other things fails to capture the relative markedness of the sounds involved. Another reason is that a [−voice] specification fails to capture the phonological behavior of these sounds, which is characteristic of aspirated rather than of voiceless segments. This last point is supported first and foremost by the observation that the presence of "voiceless" sonorants in a language almost always implies the presence of aspirated stops. For example, Botma observes that UPSID contains 24 languages with "voiceless" nasals, of which only two (Aleut and Hopi) are described as lacking aspirated stops. This would suggest that "voiceless" sonorants are more properly analyzed as being phonologically aspirated, and as such are specified in terms of [spread glottis] (e.g. **Halle and Stevens 1971**; **Lombardi 1994**) or a comparable element, e.g. |O| (**Ewen 1980**; **Anderson and Ewen 1987**) or |H| (**Botma 2005**). Notice also that if sonorancy is viewed as a manifestation of voicing, as in Dependency Phonology, a "voiceless" sonorant would be an impossible entity.

Perhaps a more contentious issue is the question of whether "voiceless" sonorants should be considered sonorants. Phonetically, there are good grounds for regarding them as fricatives: the open glottis that is characteristic of these sounds leads to high-velocity levels of egressive airflow so that, given the same vocal tract shape, "voiceless" sonorants involve local turbulence while voiced ones do not (**Ohala and Ohala 1993**; see also **CHAPTER 28**: THE REPRESENTATION OF FRICATIVES). The phonological status of "voiceless" sonorants is rather less clear. Ohala and Ohala argue that "voiceless" nasals should be analyzed as fricatives, because they frequently derive from historical sN clusters (e.g. *sN > N^h in Burmese; see **Bradley 1979**). In addition, "voiceless" sonorants tend to pattern with voiceless fricatives in tone-splitting phenomena (e.g. **Li 1977**; **Kingston and Solnit 1988**), and there do not appear to be any languages in which they can be syllabic.

Not all these arguments are equally compelling. For example, it is unclear whether the diachronic origin of "voiceless" nasals constitutes evidence for their synchronic behavior. A reasonable interpretation of the Burmese sound change in question would seem to be that /s/ debuccalized, leaving its laryngeal specification (e.g. [spread glottis], as in **Vaux 1998**) or friction component (e.g. |H|, as in **Botma 2005**) to merge with the nasal. Also, the fact that "voiceless" sonorants pattern with voiceless fricatives in tone splitting does not entail that the former *are* fricatives. A more conservative interpretation would be that the two types of sounds share a common specification, e.g. [spread glottis] or |H|.

A possible argument in favor of the sonorant status of "voiceless" sonorants is that these sounds are usually voiced for at least part of their duration. **Ladefoged (1971)** observes that this could have a perceptual motivation, in that voicing makes them more salient acoustically (see also **Ohala and Ohala 1993**). While this is certainly plausible, it does not rule out the complementary explanation that this voicing is a reflection of the sonorancy of these sounds. Notice, too, that the observation that "voiceless" sonorants are only rarely fully voiceless can be taken as an argument against analyzing them as [−voice].

Cross-linguistic studies show that "voiceless" sonorants display considerable variability in the relative order of voicing and glottal aperture, and the degree of overlap between the two (e.g. **Ladefoged and Maddieson 1996**; **Silverman 1997**; **Kehrein 2002**; **Kehrein and Golston 2004**; **Botma 2005**). Kehrein asserts that languages never make contrastive use of such variation. Similarly, Botma observes that there are no languages in UPSID which contrast "voiceless" and breathy voiced sonorants, suggesting that the two form a single phonological category; whether this category is realized as voiceless or as breathy voiced depends on whether there is overlap between the voicing and glottal aperture gestures. If correct, this would reduce the number of possible laryngeal contrasts in sonorants to two, e.g. one specified in terms of [spread glottis] (aspirated sonorants) and one in terms of [constricted glottis] (glottalized sonorants).

Following **Halle and Stevens (1971)**, glottalized sonorants are generally specified for the feature [constricted glottis] (or a comparable element, e.g. |ˀ|). These segments also display extensive phonetic variability, in terms of the degree of glottal constriction (and, related to it, the presence of voicelessness), the relative timing of glottal and supraglottal gestures, and the degree of overlap between the two. Here, too, languages never make contrastive use of these differences (**Kehrein 2002**; **Kehrein and Golston 2004**).

There is little reason to suspect that glottalization affects the sonorancy of a sound. Glottalized sonorants can apparently be syllabic in languages such as Shuswap (**Kuipers 1974**) and Columbian Salish (**Ladefoged and Maddieson 1996**), though it is likely that such sounds will involve "phasing" of the glottal and supraglottal articulations (for this notion, see **Silverman 1997**). There are also cases where glottalized sonorants display class behavior with plain sonorants. In Montana Salish, for example, plain and glottalized sonorants are both separated from a preceding obstruent by an epenthetic schwa (**Flemming *et al.* 1994**). Similarly, adjacent non-identical sonorants are generally separated by a schwa. Glottalization is ignored in establishing whether the two sonorants are identical, so that underlying sequences like /w'w/ are realized without an intervening vowel. For the purposes of epenthesis, glottalized sonorants therefore pattern with plain ones.

Summarizing, we have seen that while the status of glottalized sonorants is reasonably clear, this is much less so for voiced and aspirated sonorants. If sonorants can be specified for [voice], as is assumed in mainstream feature theory, then [voice] here does not so much reflect a laryngeal contrast as the presence of phonologically active voicing. However, what is potentially interesting is that the possibility of having [voice] appears to afford sonorants the same range of laryngeal contrasts as fricatives, viz. [voice], [spread glottis], and [constricted glottis]. (Sonorants and fricatives differ in this respect from stops, which also allow combinations of laryngeal features, e.g. [voice] *and* [spread glottis] for contrastive breathy voice.) Perhaps, then, the fact that aspirated sonorants have fricative-like characteristics means that these sounds *are* fricatives, at least on some level of representation.

3 Fuzzy class behavior: Sonorant obstruents

While the class of sonorant consonants traditionally includes liquids and nasals, it has been observed that voiced fricatives and voiced stops sometimes also pattern as sonorants, at least with respect to certain phenomena. Following **Rice (1993)**, such sounds will be referred to as "sonorant obstruents." This section considers some examples of sonorant obstruents that have been reported in the literature and discusses the kinds of arguments that have been advanced for treating these sounds as sonorants. The recognition of a class of sonorant obstruents also has repercussions for the phonetic underpinnings of sonorancy (see §4).

Consider first the following data from Turkish. In this language, syllable-final voiced plosives undergo devoicing (7a) while voiced fricatives retain their voicing in this position (7b), like sonorants (7c) (cf. **Rice 1993**: 332–333):

(7)	a.	*sara*[p]	'wine-NOM SG'	*vs.*	*sara*[b]*i*	'wine-ACC SG'
	b.	*a*[z]	'few'			
		e[v]	'house'			
	c.	*gü*[n]	'day'			
		güze[l]	'pretty'			

Two possible analyses of the Turkish pattern suggest themselves. The first limits the structural description of devoicing to stops, e.g. by specifying the targets of devoicing as [−sonorant, −continuant]. As Rice notes, the problem with this analysis is that it does little more than stipulate that devoicing is limited to stops. The alternative is to specify the voiced fricatives for the same feature as sonorants, e.g. [sonorant] or, in Rice's analysis, SV. This account is more parsimonious, since devoicing can now be restricted to whatever feature it is that obstruents have in common. In Rice's account this is the Laryngeal node, which dominates the feature [voice]. In this analysis, [voice] is therefore a property of voiced obstruents, while the voicing of sonorants, including "sonorant fricatives," is supplied by SV. Rice offers a similar account of the voiced fricatives of Athapaskan languages such as Navajo and Chipewyan.

There is reason to suspect that "sonorant fricatives" may in fact be rather widespread. For example, voiced uvular /ʁ/ and pharyngeal /ˤ/ often pattern as sonorants (e.g. **CHAPTER 25**: PHARYNGEALS). Further, /v/ has been shown to display sonorant-like behavior in languages such as Norwegian (**Kristoffersen 2000**), Russian (**Padgett 2002**), Hungarian (**Bárkányi and Kiss 2006**), and Icelandic (**Botma 2008**). **Hamann (2006)** proposes the same for German /v/, providing acoustic measurements (duration, intensity, and harmonics-to-noise ratio) which suggest that the sound is phonetically a narrow approximant. More generally, **Maddieson (1984**: 48) observes that in UPSID, "bilabial, dental and palatal non-sibilant fricatives are found to occur without a voiceless counterpart more often than with one." To the extent that this is due to a difference in markedness between voiced and voiceless fricatives (and not to diachronic lenition, say), specifying these voiced fricatives for [voice] seems ill advised. Their relative frequency could instead support an analysis in which voiceless fricatives are specified for [spread glottis] (e.g. **CHAPTER 28**: THE REPRESENTATION OF FRICATIVES). However, it might also be the case that at least some of these voiced fricatives are in fact sonorants. While such a hypothesis is phonetically feasible (vocal fold vibration leads to lower airstream velocity, making it relatively difficult to produce turbulence), it must of course be demonstrated for each of the sounds in question that they pattern as sonorants phonologically.

One type of evidence that is often adduced for the sonorant status of voiced stops is the presence of oral-nasal alternations such as [b ~ m] (e.g. **Piggott 1992**; **Rice 1993**; **Clements and Osu 2002**; **Botma 2004**). Implicit in this approach is the claim that only sonorants can be nasalized. Phonetically, this claim is not unreasonable. The presence of nasal airflow is antagonistic to the buildup of oral air pressure required for obstruents. This rules out nasalized plosives (provided a different interpretation is given to nasal contours) and makes nasalized fricatives distinctly rare. Voiced nasalized fricatives have been reported in languages such as Inor, Itsekiri, and Umbundu (see **Walker 2000** and references there), though it remains to be verified instrumentally whether these sounds are truly fricatives phonetically. **Ohala and Ohala (1993)** observe that the high rate of airflow required for friction is difficult to combine with a lowered velum, suggesting that many of the sounds described as voiced nasalized fricatives may in fact be approximants. Some phonetic studies have also reported nasal airflow in voiceless fricatives, e.g. in Coatzospan Mixtec (**Gerfen 1999**). Such nasalization seems to be possible only if there is an adjacent nasalized vowel, and so is presumably the result of co-articulation.

Oral-nasal alternations involving voiced stops occur in many languages with nasal harmony (see also **CHAPTER 78**: NASAL HARMONY). In a sub-type of nasal harmony displayed by a number of Amazonian languages, all voiced segments in the harmonic domain are nasalized, including what appear to be voiced obstruent stops phonetically. This gives rise to complementary distribution between voiced stops and nasals, as illustrated in (8) for Southern Barasano, a Tucanoan language of Colombia (cf. **Piggott 1992**: 46; see also **Smith and Smith 1971**). In this language, nasalization spreads rightwards from the leftmost nasalized vowel, skipping any intervening obstruents, as well as leftwards to an immediately preceding nasalizable consonant:

(8)	a.	*"Oral words"*		b.	*"Harmonic words"*	
		[^{m}ba^{ŋ}go ~ ^{m}bago]	'eater'		[kã̆mõ̆kã̆]	'rattle'
		[ta^{m}boti ~ taboti]	'grass'		[mã̆nõ̆]	'none'
		[^{n}diro]	'fly'		[ẽ̆õ̆nõ̆]	'mirror'
		[wesika]	'above'		[mã̆sã̆]	'people'
		[wati]	'going'		[w̃ã̆tĩ̆]	'going'

Smith and Smith (1971: 82) note that voiced stops are optionally prenasalized. Their transcriptions suggest that this prenasalization is obligatory in word-initial position.

The complementary distribution of voiced stops and nasals in Southern Barasano suggests that they share a single underlying representation. This is corroborated by patterns of allomorphy of the kind in (9) (cf. **Piggott 1992**: 47; see also **Piggott and van der Hulst 1997**):

(9)	a.	*"Oral words"*		b.	*"Harmonic words"*	
		[ji-re]	'to say'		[ɲã̆ɲõ̆-nẽ̆]	'to speak'
		[^{ŋ}gahe-ja]	'another stream'		[mĩ̆nõ̆-ɲã̆]	'leaf stream'
		[wa-^{m}bɨ]	'I went'		[ĩ̆ã̆-mĩ̆]	'I saw'

Different accounts have been offered as to the underlying representation of alternating voiced stops. According to one analysis, nasal harmony in languages like Southern Barasano targets all segments specified for [voice], nasalizing sonorants and turning voiced stops into nasals (e.g. **Pulleyblank 1989**; **Noske 1995**). The problem with this analysis is that it is stipulative, since it is unclear why voicing and nasalization should have this affinity. Alternatively, it has been suggested that this type of harmony is limited to sonorants (e.g. **Piggott 1992**; **Rice 1993**; **Botma 2004**; **Botma and Smith 2007**). This analysis implies that the voiced stops in Southern Barasano are "sonorant stops," and as such permits a uniform account of the nasalization process (see e.g. **Piggott and van der Hulst 1997**, who offer an analysis of Southern Barasano in terms of the spreading of nasality at the level of the syllable).

Botma (2009) maintains that some Amazonian languages with a similar harmony pattern, e.g. Yuhup, are best analyzed as having underlying nasals, which denasalize in certain contexts. It is reasonable to assume that this scenario mirrors the historical situation, given the cross-linguistic frequency of nasals. (Perhaps Southern Barasano represents an innovation of this pattern.) Denasalization is also the diachronic source of alternating sonorant stops in other language families. For example, **Krauss and Leer (1981)** observe that in many Athapaskan languages **m* (< **w*) and **n* have developed into /^{m}b/, /^{n}d/ (e.g. in Han, Tanacross, and Southern Slave) or into /b/, /d/ (e.g. in Tahltan, Sekani, and Bearlake Slave). In all of these languages these stops still alternate with nasals before nasalized vowels. In some of them, e.g. in Bearlake Slave, the nasal realization is also still found in certain morphological contexts (**Rice 1993**).

Further illustration of the sonorant-like behavior of voiced stops comes from West African languages such as Cama (Ebrié), Gbe, and Ikwere. For example, **Botma and Smith (2006)** observe that Cama, a Kwa language of the Ivory Coast, contrasts two types of voiced stops, which **Stewart (1973)** describes as "fortis" and "lenis", respectively. The voiced lenis stops pattern with sonorants in that (unlike the voiced fortis stops) they alternate with nasals before nasalized vowels and do not trigger tone lowering. The voiced labial stop of Gbe, a Kwa dialect cluster of Togo and Benin, also displays oral-nasal alternations, in contrast to voiced alveolar and velar stops (**Capo 1981**). This /b/ derives from an earlier implosive *ɓ, which in many African languages patterns as sonorant (e.g. **Kaye 1981**; **Clements 2000**): like sonorants, implosives have unmarked voicing, are disfavored in NC clusters, often display alternations with both liquids and nasals, and fail to trigger tone lowering.

These properties are also characteristic of the voiced "non-explosive" labial stops of Ikwere, an Igboid language of Nigeria. However, **Clements and Osu (2002**: 337) observe that these sounds do not pattern with sonorants with respect to their "sonority-related distributional properties," nor do they behave as sonorants with regard to suprasegmental aspects such as tone and weight. This ambivalence appears to be representative of sonorant obstruents in general, and suggests that the internal structure of these sounds contains both obstruent and sonorant properties. To this end, Clements and Osu propose two distinct binary features, [obstruent] and [sonorant]. The former is an articulatory feature defined in terms of "air pressure build-up in the oral cavity," the latter an acoustic feature defined in terms of "a periodic, well-defined formant structure" (cf. **Clements and Osu 2002**: 338). Sonorants in this account are [−obstruent, +sonorant], while non-explosives are [−sonorant, −obstruent]. This captures the observation that non-explosives display class behavior with both sonorants (which are also [−obstruent]) and obstruents (which are also [−sonorant]).

One issue that is raised by this account is whether the combination [+obstruent, +sonorant] denotes an impossible phonetic entity or whether, as **Clements and Osu (2002**: 338) speculate, it specifies "laxly articulated fricatives" – the sounds referred to as sonorant fricatives above. Whether sonorant fricatives are uniformly characterized by a well-defined formant structure is an empirical question, for which more research is needed. However, notice that there do not appear to be any clear-cut cases where voiced fricatives pattern as sonorants in respect of tonal or moraic aspects, nor do there seem to be any languages where such sounds can be syllabic.

An alternative and perhaps more restrictive approach to the representation of sonorant obstruents would be in terms of a difference in the relative prominence of periodicity, similar to van der Hulst's dependency-based approach to sonorancy and voicing (see §2.1). **Botma and Smith (2006)** offer an account along these lines for Cama, a language with a stop system similar to that of Ikwere. Consider the representations in (10), where both sonorants (10a) and sonorant stops (10b) contain the elements |L| and |ʔ|, which have the acoustic correlates of "periodicity" and "amplitude drop" respectively (for discussion of the interpretation of elements, see e.g. **Harris and Lindsey 1995**; **Harris 1996**; **Botma 2004**):

(10) a. *Sonorant* b. *Sonorant stop*

a. *Sonorant*	b. *Sonorant stop*
Root	Root
|	|
L	ʔ
|	|
ʔ	L

Sonorants thus have relatively prominent periodicity as compared to sonorant stops, as formalized by the head status of |L| in the former. A general advantage of such an approach is that the dominant element is linked directly to the root node, and is as such "visible" to the prosodic structure. This is in line with the observation, made at the outset of this chapter, that the most straightforward evidence for class behavior of sonorants seems to come from their patterning with respect to suprasegmental aspects such as syllable structure, moraic structure, and tone.

Summarizing, we have seen in this section that the class of sonorants is not always sharply delineated, in that it may also include voiced stops and fricatives. The available evidence suggests that such "sonorant obstruents" pattern with sonorants with respect to some properties but not others. Clements and Osu conjecture that true sonorants behave as a class with respect to prosodic aspects, and may pattern with sonorant obstruents with respect to segmental aspects. Further research must determine whether this hypothesis can be maintained. Notice, for example, that this hypothesis is not easily compatible with an analysis of Southern Barasano in which nasal harmony operates at the level of the syllable (as is argued by Piggott and van der Hulst), given that sonorant stops should pattern as obstruents at this level.

4 How should sonorancy be defined phonetically?

The evidence considered in the preceding sections suggests that a phonological feature (or comparable unit) representing sonorancy is warranted. A widely accepted assumption in this respect is that the features which are relevant in accounting for phonological patterns have a phonetic basis (though see e.g. **Hjelmslev 1953**, **Capo 1981**, and **Hale and Reiss 2000** for an opposing view). However, the problem is that the phonetic correlates of the feature [sonorant] are far from straightforward. While this is perhaps not a strictly phonological problem (but one which concerns the phonetics-phonology interface), it nevertheless requires some discussion, particularly in view of the potentially sonorant-like behavior of voiced stops and fricatives discussed in §3.

Part of the problem with the phonetic underpinnings of sonorancy is that the correlates of sonority, a notion related to sonorancy, have repeatedly been called into question (e.g. **Malsch and Fulcher 1989**; **Nathan 1989**; **Ohala 1990**; **Harris 2006**). Consider for example intensity, which has been argued to be one of the correlates of sonority (e.g. **CHAPTER 49**: SONORITY). Harris observes that the intensity values of strident fricatives, in particular /s/, can be higher than that of nasals, which are considered more sonorous than stridents (based on the observation that in initial clusters nasals follow rather than precede /s/, e.g. English *snow* but **nsow*).

This problem does not necessarily carry over to sonorancy. The feature [sonorant] can be thought of as imposing a binary partition on the sonority scale, a minimal version of which is given in (11). (**Harris 2006**: 1485 notes that finer-grained versions of the scale "usually come with the rider that they are subject to cross-linguistic variation," though such sonority conversions have in fact also been suggested for semi-vowels and liquids; see e.g. **Hankamer and Aissen 1974**.)

(11) vowels > semi-vowels > liquids > nasals > fricatives > plosives

Given (11), a phonetic definition of [sonorant] need therefore characterize only the properties that vowels, semi-vowels, liquids, and nasals have in common to the exclusion of fricatives and plosives. To this end, both articulatory and acoustic characterizations of sonorancy have been proposed in the literature. These are reviewed in §4.1, where we will see that the most straightforward characterization of sonorancy is an acoustic one, involving the presence of a clearly marked formant structure. §4.2 addresses the question to what extent the class behavior of sonorants and sonorant obstruents can be considered phonetically natural. On the basis of the available evidence, the answer seems to be that sonorants and sonorant obstruents are both voiced, with the voicing in the latter guaranteed by "active voice facilitation." However, we will see that in at least some cases, aerodynamic correlates of sonorancy may also be relevant.

4.1 Phonetic definitions of [sonorant]

Much work in mainstream generative phonology, in particular in Feature Geometry, has continued to assume the articulatory feature characterizations espoused in *SPE*, where segments specified as [+sonorant] are defined as "sounds produced with a vocal tract configuration in which spontaneous voicing is possible" (**Chomsky and Halle 1968**: 302). Strictly articulatory approaches to features have been criticized on the grounds that they are unable to account for phenomena that are acoustically motivated, such as the frequent interaction between labials and velars (e.g. **Hyman 1973**). The appropriateness of an articulatory characterization of [sonorant] has also been questioned, perhaps most notably in the work of **Ladefoged (e.g. 1971, 1982, 1997)**, who maintains that sonorancy is best defined in acoustic terms, in line with the previously dominant approach to features of **Jakobson *et al.* (1952)**.

Central to the *SPE* approach to sonorancy is the notion of "spontaneous voicing," which Chomsky and Halle claim is different from obstruent voicing, both phonologically and phonetically. The former claim is also the main tenet of the SV hypothesis, as we have seen in §2.1. However, it is not clear whether proponents of this hypothesis also take sonorant voicing to be phonetically distinct from obstruent voicing (cf. e.g. **Rice 1993**: 341), nor is it clear whether in the SV approach distinct features are required to have distinct phonetic correlates.

There are two general problems with spontaneous voicing as used in *SPE*. The first is that while in *SPE* spontaneous voicing is a key ingredient of sonorancy, Chomsky and Halle's definition does not in fact require sonorants to be voiced. This has a number of unfortunate consequences. One of these concerns the interpretation of "voiceless" sonorants, which are usually voiceless (at least for part of their duration; see §2.3) despite the fact that their vocal tract shape is conducive to voicing. Another is that in *SPE* the set of [+sonorant] segments includes the laryngeals, [h ʔ]. While these are like sonorants with respect to their vocal tract shape, their laryngeal setting is antagonistic to voicing, and for [ʔ] is in fact incompatible with it. This leads **Ladefoged (1971**: 109) to qualify this proposal as "counter-intuitive to say the least." An analysis of [h ʔ] as sonorants is also dubious on phonological grounds. Consider the interpretation of the lenition processes in (12), both of which are common sound changes in languages of the world (see e.g. **Campbell 2004** for examples).

(12) a. f s x > h
b. p t k > ʔ

McCarthy (1988) argues that these processes are best treated as involving the loss of oral place features, which leaves behind segments specified for laryngeal structure only. According to this interpretation, [h ʔ] are therefore "defective" obstruents, like the "complete" obstruents from which they are derived. Notice further that [h ʔ] also do not display class behavior with sonorants with respect to the properties mentioned in §1. Laryngeals are never syllabic or tonal, nor do there seem to be any languages in which they are weight-bearing to the exclusion of non-sonorants.

The second problem with spontaneous voicing is that the phonetic evidence which Chomsky and Halle adduce for it is questionable, as pointed out by **Ladefoged (1971)**, among others. Twenty-five years later, in joint work with Maddieson, Ladefoged sees no reason to change this view:

> The physiological position for modal voice can be regarded as one in which the arytenoid cartilages are in a neutral position for speech, neither pulled apart nor pushed together (**Stevens 1988**). The vocal folds would be very slightly apart, if there were no air flow. We assume that the same position as occurs in ordinary voiced vowels and in voiced continuant consonants such as nasals is normally maintained in stops that are phonologically voiced. (**Ladefoged and Maddieson 1996**: 50)

If sonorants and voiced obstruents do not differ in the laryngeal physiology of their voicing, then the difference between them must lie in the effect that the supralaryngeal configuration has on vocal fold vibration. Sonorants involve an unconstricted vocal tract, so that in these sounds sustained voicing is possible. Obstruents, on the other hand, involve a constricted vocal tract, which for aerodynamic reasons inhibits vocal fold vibration (e.g. **Ohala 1983**). The effect of this is that voiced obstruents lack a well-defined formant structure. This is presumably the reason why in many languages sonorants behave as a class to the exclusion of both voiceless and voiced obstruents. A case in point is a language like

Dutch, where final devoicing targets voiced obstruents (13a) but leaves sonorants unaffected (13b).

(13)	a.	*bed*	/bɛd/	[bɛt]	'bed'	cf.	[bɛd-ə]	'beds'
		reis	/rɛis/	[rɛis]	'journey'		[rɛiz-ə]	'journeys'
	b.	*bel*	/bɛl/	[bɛl]	'bell'		[bɛl-ə]	'bells'
		trein	/trɛin/	[trɛin]	'train'		[trɛin-ə]	'trains'

For a detailed discussion of final devoicing in Dutch and other languages, see e.g. **Warner *et al.* (2004)**, **CHAPTER 69**: FINAL DEVOICING AND FINAL LARYNGEAL NEUTRALIZATION, and references there.

A possible challenge to the claim that sonorants and obstruents do not differ in the physiology of their voicing comes from tone. Research on tone languages has shown that obstruent voicing often conditions a lower tone on a following vowel, and is in many cases the diachronic origin of low tone (e.g. **Matisoff 1973**; **Bradshaw 1999**; **Yip 2002**; see also **CHAPTER 97**: TONOGENESIS). Sonorants generally do not have such an effect, although there are exceptions, such as in Ewe (**Smith 1968**, cited in **Yip 2002**). It could therefore be suggested that the characteristics of obstruent voicing differ from those of sonorant voicing after all. This is the position taken by e.g. Yip, who, following **Halle and Stevens (1971)**, maintains that voiced obstruents involve slacker vocal folds than sonorants. The reasoning behind this is aerodynamic: the oral constriction characteristic of obstruents raises the supraglottal air pressure, which slows down the rate of vocal fold vibration; to counteract this, the vocal folds are slackened, which lowers the pitch of a following vowel. The degree of oral constriction in sonorants, on the other hand, does not raise the air pressure to such an extent that this inhibits vocal fold vibration.

While this is not the place to focus on consonant–tone interaction in any detail, a couple of brief comments are in order. The experimental findings reported in **Hombert *et al.* (1979)** show that both voiced obstruents and sonorants trigger pitch lowering in a following vowel, both in tonal languages like Yoruba and in non-tonal ones like English. This is unexpected if obstruent-induced lowering is caused by aerodynamic factors. Hombert *et al.* reject this kind of explanation, arguing instead that in voiced obstruent stops the larynx is actively lowered during the latter part of the stop's closure phase, and that this is responsible for pitch lowering. However, as Hombert *et al.* themselves note, this account, too, fails to explain why sonorants, whose realization does not normally involve downward movement of the larynx, also lower the pitch of a following vowel.

If the phonetic lowering effect of both sonorants and voiced obstruents is indeed typical of languages in general, then it remains unclear why obstruent voicing often has phonological effects, while sonorant voicing usually does not. It could be the case that listeners for some reason do not factor in the lowering effect of sonorants, perhaps because sonorants are more readily identified as the locus of vocal fold vibration than obstruents. But whatever the explanation for their different tonal effects, it does not necessarily imply that sonorants and obstruents employ distinct voicing mechanisms.

The fact that it has proved difficult to find any substantial phonetic evidence for the notion of spontaneous voicing is perhaps the reason why some later definitions of sonorancy, while maintaining a view that is very close to that of *SPE*, avoid the use of this term. The following definition, taken from a textbook which at the time offered the most exhaustive overview of mainstream generative phonology, is a case in point:

> [±sonorant] classifies sounds in terms of the effect their stricture has on the flow of air across the glottis and hence the capacity to induce vibration of the vocal cords. (**Kenstowicz 1994**: 36)

Other post-*SPE* definitions of sonorancy, while still fundamentally articulatory, focus not so much on the vocal tract shape of sonorants but on its aerodynamic consequences. For example, **Halle and Clements (1983)** offer the following definition (for similar definitions, see **Stewart 1989**, **Halle 1992**, and **Stevens 1998**):

> Sonorant sounds are produced with a vocal tract configuration sufficiently open that the air pressure inside and outside the mouth is approximately equal. Obstruent sounds are produced with a vocal tract constriction sufficient to increase the air pressure inside the mouth significantly over that of the ambient air. (**Halle and Clements 1983**: 6)

However, notice that this characterization does not make any reference to voicing, despite the fact that sonorants are naturally voiced.

Ladefoged (1997: 615), on the other hand, regards voicing as an essential aspect of sonorancy. He observes that the most straightforward way to identify sonorants is not in terms of the physiology of this voicing but in terms of its acoustic effect (see also **Lass 1984**; **Anderson and Ewen 1987**; **Giegerich 1992**; **Clements and Osu 2002**; **CHAPTER 98**: SPEECH PERCEPTION AND PHONOLOGY):

> The notion of "spontaneous voicing" …does not get at the essence of what it is that causes vowels, nasals, laterals and some approximants to be grouped together. Better articulatory statements can be made in terms of the function of the articulatory system as a whole: sonorant sounds are those in which the vocal folds are

> vibrating and there is no significant build up of oral pressure. But if we are to claim that the feature Sonorant has this kind of articulatory basis, then we must claim that vocal fold vibrations and lack of pressure are both sensed by a speaker, and then combined so that together they are considered to form a salient psychological percept. This is a rather far-fetched notion for which there is no evidence. The fact that a feature can be defined in a certain way does not mean that this definition is any help in explaining why the feature groups sounds together into a natural class. Sonorant sounds are clearly related by having a periodic, well-defined, formant structure. They behave the same way within a language not because they are made alike, but because they sound alike. (**Ladefoged 1997**: 615)

This characterization seems adequate as a phonetic basis for class behavior of sonorants, although it departs from the articulatory approach to features assumed in *SPE* and Feature Geometry.

4.2 Phonetic correlates of sonorant obstruents

A traditional assumption in phonology is that a natural class of sounds recurrently participates in phonological processes and shares some phonetic property to the exclusion of other sounds (e.g. **Hyman 1975**; **Ewen and van der Hulst 2001**). To the extent that the patterning of voiced stops and fricatives with sonorants is recurrent, we would therefore also expect this to be the case for sonorants and sonorant obstruents. The alternative would be to argue that the existence of sonorant obstruents provides evidence for the view that phonological classes can be phonetically unnatural. This is the position taken in **Blaho and Bye (2005)** and **Tuttle (2005)**, who refer to sonorant obstruents as "cryptosonorants." This position is in principle consistent with the view that phonological patterns are not necessarily motivated by synchronic phonetic factors (e.g. **Capo 1981**; **Blevins 2004**; **Silverman 2006**).

Whether such a view is required to account for the patterning of sonorant obstruents remains to be seen, however. The available data seem to indicate that sonorant obstruents are realized with sustained voicing. If this is true of such sounds in general, then their class behavior with sonorants would follow naturally from the assumptions that (i) sonorancy correlates with relative prominence of periodic energy, and (ii) the category of sonorants is not determined universally, but depends on how individual languages partition the voicing continuum (similar to what **Mielke (2005)** claims is the case for the continuant status of nasals and laterals).

Let us consider the voicing characteristics of sonorant obstruents in somewhat more detail. We have already seen that the vocal tract shape of obstruents inhibits voicing, so that sustained vocal fold vibration in these sounds requires special measures. Obstruent voicing can be facilitated either passively, through relaxation of the soft tissues of the supraglottal walls, or actively, through lowering of the larynx, the jaw, or the velum, by advancing the tongue root, or by effecting a shorter closure duration (e.g. **Perkell 1969**; **Catford 1977**; **Ohala and Riordan 1979**; **Ohala 1983**; **Ladefoged and Maddieson 1996**; **Stevens 1998**; **Clements and Osu 2002**). These types of voice facilitation have been observed in a variety of languages, including in stops which are normally voiced for only part of their duration, such as the lenis stops of English (e.g. **Westbury 1983**).

Voice facilitation is also a property of sonorant obstruents. For example, in his discussion of Southern Barasano, **Piggott (1992**: 48) asserts that alternating voiced stops predictably have a nasal phase, which is "directly deriveable from the articulatory adjustments required to realize spontaneous voicing." This claim is overly restrictive, however. Aside from the fact that such nasalization is often variable (as in Southern Barasano itself, but also in Athapaskan languages like Slave; see **Rice 2006**), sonorant stops may lack a nasal phase altogether. This is the case, for example, for the sonorant stops in Cama, Gbe, and Ikwere, which were discussed in §3. On the basis of the available descriptions, it seems that the best that can be said is that sonorant stops are consistently realized with *active* voice facilitation, and that the degree of voice facilitation is such that these sounds are voiced throughout their duration.

Thus, while the presence of voice facilitation cannot be used as a diagnostic for the sonorant status of a sound, two reasonable hypotheses can be made. The first is that active voice facilitation is a prerequisite for sonorant but not for obstruent stops. The second is that in languages where sonorant stops contrast with obstruent stops, the former involve a greater degree of voice facilitation than the latter. Support for the latter hypothesis comes from Bearlake Slave, a Northern Athapaskan language, which contrasts plain, aspirated, and ejective stops, and an additional series of voiced alternating stops. The description in **Rice (1994, 2006)** suggests that the realization of the plain stops is similar to the lenis stops of English. The voiced alternating series, on the other hand, is fully voiced and optionally prenasalized, suggesting a greater degree of voice facilitation. This phonetic difference correlates with a phonological difference. The two types of stops behave differently under perfective formation, where alternating stops are nasalized (14a) while non-alternating ones remain unaffected (14b) (cf. **Rice 1993**: 322–333; the vowel changes are due to an independent ablaut process):

(14) a. *Alternating stops*

-de 'win-IMPERF'
-nõ 'win-PERF'

b. *Non-alternating stops*

-da 'move-IMPERF'
-dõ 'move-PERF'

Rice analyzes the alternating stops as sonorants, specified for an SV node, and the plain stops as obstruents, unspecified for any laryngeal structure.

Some cases of class behavior of sonorant obstruents and sonorants appear to support the relevance of aerodynamic aspects of sonorancy. The most compelling evidence for this comes from Ikwere (**Clements and Osu 2002**). This language has a contrast between voiceless and voiced "explosive" stops, and an additional contrast between voiced and glottalized labial "non-explosive" stops. We saw in §3 that the latter display sonorant-like behavior (they alternate with nasals, do not occur in NC-clusters, and fail to trigger tone lowering). Clements and Osu transcribe the non-explosive stops as /ḅ/ and /ʼḅ/, noting that they derive from historical labial-velars. Phonetically, /ḅ ʼḅ/ are non-implosive, and they are characterized by the absence of heightened air pressure. /'ḅ/ is pre-glottalized, and as a result voiceless throughout the initial part of the closure phase; the latter part of /ʼḅ/ has modal voicing. /ḅ/ has modal voicing throughout. Importantly, the same is true of the voiced explosive /b/, which also has roughly the same duration as /ḅ/. The contrast between /b/ and /ḅ/ thus resides first and foremost in their air pressure characteristics. This difference certainly also leads to an acoustic difference (otherwise children acquiring Ikwere would not be able to discriminate between the two sounds), but Clements and Osu's data show that this difference does not seem to lie in the sounds' voicing characteristics. If the class behavior of non-explosives with sonorants is taken to be phonetically natural, then this can be achieved either by extending the correlates of sonorancy to include air pressure characteristics or, as Clements and Osu argue, by differentiating between an acoustic feature [sonorant] and an articulatory/aerodynamic feature [obstruent].

Alternatively, it might be argued that the phonetic motivation for class behavior of non-explosives with sonorants lies in the history of Ikwere. Such an account would have to show that the historical labial-velars can be reasonably treated as acoustically closer to sonorants. It is worth noting in this respect that labial-velars are sometimes produced with an ingressive airstream mechanism (e.g. **Ladefoged 1968**; **Cahill 2008**). This makes them similar to implosives, which frequently pattern as sonorants (see §3). It is also worth noting that Ikwere /ḅ ʼḅ/ are velarized, which, as Clements and Osu suggest, may be a reflex of their earlier velar articulation (cf. also **Ladefoged and Maddieson 1996**: 89, 343). Clements and Osu conjecture that velarization expands the oral cavity to such an extent that the non-explosive release of /ḅ ʼḅ/ is characterized by ingressive airflow, though, as noted, this does not appear to lead to more prominent voicing.

5 Discussion and Conclusion

This chapter has considered three issues in the phonology of sonorants: (i) the representation of sonorancy in segmental structure (and its relation to laryngeal contrasts); (ii) the interpretation of fuzzy class behavior of sonorants and sonorant obstruents; and (iii) the phonetic correlates of sonorancy. As the preceding discussion makes clear, the thread that runs through these issues is the relation between sonorancy and voicing.

The main challenge facing a theoretical interpretation of sonorancy is to provide an adequate account of the observation that voicing is never contrastive in sonorants, but may nevertheless be required in their phonological specification. A further challenge concerns the observation that if voicing is not contrastive in sonorants, then sonorants evidently entertain a different relationship with laryngeal contrasts than do other segment types, such as stops and fricatives. It would seem that none of the segmental theories currently on offer can account for this difference in any straightforward way. A further challenge is posed by the class of "voiceless" aspirated sonorants, whose sonorant status is not entirely clear.

The relation between sonorancy and voicing is also relevant in the interpretation of fuzzy class behavior of sonorants and voiced stops and fricatives. In some languages where this is observed, such as Southern Barasano, the relevant class consists of all voiced sounds of the language, viz. sonorants and voiced stops, suggesting that the latter function phonologically as sonorants. In other languages, such as Cama and Bearlake Slave, some voiced sounds pattern with sonorants whereas others do not. In such languages, it appears to be the case that the sonorant obstruents involve active voice facilitation, manifested phonetically by such gestures as prenasalization and implosion, making their voicing more prominent than that of their voiced obstruent congeners.

Finally, the relation between sonorancy and voicing is also important with regard to the phonetic underpinnings of sonorant class behavior. There is good reason to believe that class behavior of true sonorants is phonetically natural in that these sounds are characterized by a clearly defined formant structure, an acoustic property which sonorants share to the exclusion of other sounds. Such a characterization is not only simpler than an articulatory one but also avoids the dubious notion of spontaneous voicing, for which little phonetic support has been found. The class behavior of sonorants and sonorant obstruents seems natural to the extent that both involve sustained vocal fold vibration. However, in some languages, such as Ikwere, sonorant stops do not appear to differ from their obstruent counterparts in terms of their voicing characteristics, suggesting that in this language sonorancy correlates with a combination of periodicity and lack of supraglottal air pressure buildup. While this is perhaps a "far-fetched notion," as Ladefoged asserts, there is recent evidence that listeners do indeed make use of the multi-sensory integration of perceptual events. **Gick and Derrick (2009)** show that *pa*/*ba* syllables are more likely to be heard as aspirated by English listeners (i.e. causing them to mishear *b* as *p*) when these are accompanied by cutaneous air puffs at the right hand or the neck, suggesting that information from the auditory and the tactile domain may combine to form a salient psychological percept. We should not be surprised, then, to find that similar multisensory integration is found within the auditory domain itself.

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