Proposal for superscript diacritics for prenasalization, preglottalization and preaspiration

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The IPA currently does not specify how to represent prenasalization, preglottalization or preaspiration. We first review some current transcription practices, and phonetic and phonological literature bearing on the unitary status of prenasalized, preglottalized and preaspirated segments. We then propose that the IPA adopt superscript diacritics placed before a base symbol for these three phenomena. We also suggest how the current IPA Diacritics chart can be modified to allow these diacritics to be fit within the chart.

1 Introduction

The IPA provides a variety of diacritics which can be added to base symbols in various positions: above ([ã]), below ([n̥]), through ([ɫ]), superscript after ([tʰ]) or centered after ([ɚ]) . Currently, IPA diacritics which modify base symbols are never shown preceding them; the only diacritics which precede are the stress marks, i.e. primary ([ˈ]) and secondary ([ˌ]) stress. Yet, in practice, superscript diacritics are often used preceding base symbols; specifically, they are often used to notate prenasalization, preglottalization and preaspiration. These terms are very common in phonetics and phonology, each having thousands of Google hits. However, none of these phonetic phenomena is included on the IPA chart or mentioned in Part I of the *Handbook of the International Phonetic Association* (IPA 1999), and thus there is currently no guidance given to users about transcribing them. In this note we review these phenomena, and propose that the Association's alphabet include superscript diacritics preceding the base symbol for prenasalization, preglottalization and preaspiration, in accord with one common way of transcribing them.

Given that the IPA chart does not exemplify these phenomena, it is unsurprising that current usage is varied. For example, while most textbooks do not mention these phenomena, in those textbooks and reference works that do cover them, each offers a different possible notation. In the case of preaspiration, the extended IPA of the International Clinical Phonetics and Linguistics Association (in the *Handbook*) does specify a notation with a preceding superscript diacritic, e.g. [ʰp], and Ball & Rahilly's (1999: 73–74) textbook presents this. Ashby (2011: 128–129) uses a similar diacritic for allophonic preglottalization, e.g. [ˀt], and Laver (1994) notates all three phenomena with a preceding superscript diacritic.[1] On the other hand, some textbooks (Ladefoged 1975 and later editions; Catford 1988: 114; Rogers 2000: 224) transcribe prenasalization as a sequence of two symbols, e.g. [nd].[2] Rogers

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[1] Laver sometimes uses a sequence for preglottalization in English. However, in the case of nasal+oral sequences, he notes that use of diacritics is crucial for distinguishing pre-nasal oral stops from post-occluded nasal stops.

[2] These texts also transcribe nasal RELEASE as sequences, e.g. [dn], presumably because they largely pre-date the Kiel Convention's inclusion of a nasal release diacritic in the IPA (e.g. [dⁿ]) .

Table 1 Transcription of prenasalization/preaspiration/preglottalization in *JIPA*, 2001–2017, and in Illustrations of the IPA published in the *Handbook* of the IPA (IPA 1999).

	Prenasalization	Preaspiration	Preglottalization
Superscript	Riehl & Jauncey (2005)	Kruspe & Hajek (2009)	Carlson et al. (2001)
	Makasso & Lee (2015)	Nance & Stuart-Smith (2013)	Anonby (2006)
	Evans & Miller (2016)		DiCanio (2010)
	Elliott et al. (2016)		Brown et al. (2016)
	Nabirye et al. (2016)		
Sequence	Donohue (1999)	(none)	Baird (2002)
	Baird (2002)		
	Olson (2004)		
	DiCanio (2010)		
	Chirkova & Chen (2013)		
	Chirkova et al. (2013)		
	Hamann & Kula (2015)		
Sequence with tie bar	Dawd & Hayward (2002)	(none)	(none)
	Tench (2007)		
No transcription	(none)	Watson (2007)	(none)
		DiCanio (2010)	

(2000: 55) also uses a sequence of symbols for preglottalization, but adding a tie bar, e.g. [$\widehat{\text{ʔt}}$]. Similarly, Ladefoged & Maddieson (1996: 74, figure legend) show a sequence with a tie bar for allophonic (pre)glottalization, but without a tie bar for preaspiration and prenasalization.

Likewise, various research articles published in the *Journal of the International Phonetic Association* and elsewhere exhibit these transcription options. Most strikingly, this is true of the Illustrations of the IPA of languages with these sounds published in the *Handbook* and in *JIPA* since 2001. Table 1 summarizes the practice of these Illustrations. For example, four Illustrations mention preglottalization. Carlson, Esling & Fraser (2001) on Nuuchahnulth, Anonby (2006) on Mambay,[3] and DiCanio (2010) on Itunyoso Trique all use a preceding superscript, e.g. [ˀm], while Baird (2002) on Keo uses a sequence beginning with a full glottal stop, e.g. [ʔb]. Presentations of prenasalization are the most varied, and the most common, with the superscript diacritic in the minority. In contrast, preaspiration is rare in Illustrations, but both presentations use the superscript diacritic. It is noteworthy that none of these Illustrations mentions that these phenomena do not appear in the IPA's presentations of its symbols.[4]

Research articles in *JIPA* and elsewhere show a similar variety. For preaspiration, there is a clear preference for the superscript diacritic (Helgason 2002 on Nordic languages, Silverman 2003 on many languages, Hoole & Bombien 2010 on Icelandic, Karlsson & Svantesson 2011 on Mongolian, Clayton 2017 on Hebrides English), though Gordon (1996) uses a sequence for Hupa (also see below for other uses of sequences). For prenasalization, sequence notation is common (Stanton 2015), but when specifying that a single segment is involved, superscripts are seen (Cohn & Riehl 2012, Ratliff 2015). For preglottalization, sequences are common (Roengpitya (1997) on Lai, Keller (2001) on Brao-Krung; Roach (1973) and MacMahon (2006) for English), but Esling and his colleagues generally use a superscript, e.g. Carlson et al. (2001) on Nuuchahnulth (exceptions include Edmondson et al. (2004), who use a sequence, and Esling, Fraser & Harris (2005), who use a superscript with a tie bar for English).

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[3] Anonby uses the creaky diacritic together with the superscript diacritic.

[4] Watson (2007) uses a notation from the Extended IPA for a different phenomenon, but does not use the notation for preaspiration available there.

Thus we find ourselves in a situation where many researchers need to refer to these phenomena, but the IPA offers no guidance. The current proliferation of transcription practices, even in our own *Journal*, is the result. In what follows, we review the literature on the phonetics and phonology of prenasalization/preglottalization/preaspiration, showing that these phonetic phenomena are sufficiently well-established to merit a fixed, dedicated IPA representation.

2 Literature on the phonetics and phonology of these phenomena

In this section we summarize phonetic evidence that in prenasalization/preglottalization/ preaspiration, the interval of nasalization/glottalization/aspiration comes first, and that it can form part of a single complex phonetic segment, with a single primary oral constriction, rather than a two-segment cluster. We then report on phonological evidence that the prenasalized, preglottalized or preaspirated segments can pattern like single segments rather than like clusters, and can contrast with phonetically similar segments within a language. Thus, although there is a sequence of phonetic events, it is considered to be a single segment phonetically and/or phonologically. Throughout, we retain the original authors' transcriptions.

2.1 Prenasalization

Prenasalization is generally defined as a nasal–oral sequence which is often homorganic and which functions as a single unit, often with reference to its occurrence as a syllable onset (e.g. Catford 1988, Ladefoged & Maddieson 1996). Maddieson & Ladefoged (1993:254) report that about 12% of the languages in UPSID (Maddieson 1984) contain prenasalized phonemes, making prenasalization the most common of the three phenomena treated in our proposal. (In contrast, nasal release occurs in only one language in UPSID.) A bibliography of some 50 languages with prenasalized consonants is given as an appendix in Stanton (2015), which also cites previous cross-language studies. Ratliff (2015) surveys the incidence of prenasalization in Mainland South East Asian languages.

2.1.1 Phonetics

It is uncontroversial that in prenasalized sounds, a nasal interval comes before an oral interval: the velum is first lowered, then raised (e.g. Burton, Blumstein & Stevens (1992), Beddor & Onsuwan (2003), Riehl (2008); see Stanton (2015) for additional references). Cohn & Riehl (2012) noted that in many Austronesian languages, vowels after prenasalized consonants are oral, while after nasals, vowels are nasalized; that is, the right edge of a prenasalized consonant is fully oral.

More controversial is whether they are unitary, though complex, segments. Herbert (1976) suggested that prenasalized segments should have the phonetic duration of a single segment, else they should be considered clusters of two segments. Studies of several languages have presented this kind of argument; see Stanton (2015) for a summary of this literature, and also Avram (2010), Rivera-Castillo (2013). For example, Maddieson (1989) shows that Fijian prenasalized consonant durations match those of voiceless stops and /l/, and durations of vowels before the various consonants are likewise similar.

Nonetheless, it is clear that languages differ in the relative durations of their prenasalized segments; for example, Cohn & Riehl (2012) examined NC (nasal consonant–oral consonant) sequences in six Austronesian languages, some already thought to be clusters, and others of unknown status. They found three different duration patterns, one of which was clearly compatible with a unitary segment. Henton, Ladefoged & Maddieson (1992)/Ladefoged & Maddieson (1996) discuss the problems with duration-based arguments, but it seems that in some languages, though certainly not all, prenasalized segments do have the durations of single segments.

2.1.2 Phonology

Regardless of whether prenasalized consonants have durations that mark them as likely single segments, they are often analyzed as single phonological segments. Indeed, status as single phonological segments is part of the definition of prenasalized consonants given by Catford (1988), Ladefoged & Maddieson (1996), and Riehl (2008). Several kinds of arguments for such analyses are seen in the literature (see e.g. Feinstein 1979 for discussion). The first – and by far the most commonly offered – is that prenasalized consonants have the distribution of single segments. This can be especially clear in languages without clusters or coda consonants. For example, Maddieson (1989) cites Geraghty's (1983) unitary analysis of Fijian prenasalization. In Fijian, there are no (other) consonant sequences – no onset clusters, no coda consonants. If prenasalized consonants were treated as sequences, they would be the only instances of onset clusters or coda consonants in the language. Keenan & Chung (2017) have recently made the same argument in favor of prenasalized segments in Malagasy. As Stanton (2015) notes, given a choice of complicating the inventory or the phonotactics of a language, analysts will mostly choose to add to the inventory. Similarly, it is often pointed out that prenasalized consonants can occur initially, where they are unlikely clusters given their decreasing sonority (though cf. Riehl 2008: Section 1.3). In some languages, e.g. Nara (Illustration of the IPA by Dawd & Hayward 2002), the prenasalized plosives occur only in onset position. Nonetheless, exceptions are found. Tataltepec Chatino (Sullivant 2015) has initial phonetic prenasalized voiced stops which, unlike nasal stops, do not bear tone. They would thus seem to be units, and analyzing them as NC sequences complicates the phonotactics of the language. However, Sullivant analyses them as exceptional sequences on the basis of morphology: the nasal portion is a separate morpheme which word-internally appears as a full nasal stop. When this morpheme appears before a word-initial oral stop (which in this language are all voiceless), a general pattern of post-nasal voicing creates a phonetic prenasalized voiced stop.

Another kind of argument is that prenasalized consonants contrast with NC sequences, and thus cannot be analyzed as sequences. As Laver (1994: 229) says: 'it would be persuasive if languages could be found where words are contrastively identified by means of these complex stops versus comparable sequences of their simple nasal and oral stop counterparts'. However, the cases of this kind cited by Laver do not involve simple NC sequences like [mb]; rather, they involve either N:C sequences with long nasals (e.g. Sinhalese, Jones 1950: 79–81, cited by Laver) or N̩C sequences with syllabic nasals (e.g. Nyanja, Herbert 1986: 161; Tiv, Arnott 1969; another such case is Swahili adjective forms (Hinnebusch & Mirza 1998, cited by Mwita 2007)). For example, Arnott shows that in word-initial position Tiv contrasts prenasalized stops with plain voiced and voiceless stops, and with nasals and syllabic (tone-bearing) nasals – e.g. /mbàrá/ contrasts with /pá/, /báŕ/, /mátó/ and /ḿ-kèḿ/. The syllabic (tone-bearing) nasals are distinct from the prenasalized consonants.

(1)   Tᴏʜᴏᴋᴜ   Tᴏᴋʏᴏ   Eɴɢʟɪsʜ ɢʟᴏss

     [ɸuda]   [ɸuta]   'lid'
     [ɸuⁿda]   [ɸuda]   'tag/label'
     [ɸunda]   [ɸunda]   'step-Past'

     [saᵐba]   [saba]   'mackerel'
     [samba]   [samba]   'midwife'
     [sama]   [sama]   'appearance/look'
     [samːa]   [samːa]   'saury (fish)'

Those Japanese dialects with both prenasalized stops and NC sequences perhaps make a more compelling case. In some north-eastern (Tohoku) dialects of modern Japanese, prenasalized intervocalic consonants are attested; they are thought to have been preserved from Old Japanese (Vance, Miyashita & Irwin 2014). These prenasalized consonants contrast with NC sequences and with Nː (examples from Yu Tanaka, p.c.), as seen in (1). It is possible that the moraic status of nasal consonants enhances this contrast; certainly this case merits further study.

On the other hand, something of the opposite argument from inventory gaps is sometimes made for unitary status. For example, Riehl (2008) takes the ABSENCE of plain nasals and/or plain voiced stops as the clearest evidence for the unitary status of prenasalized stops. The idea is that if a language lacks, e.g. /n/ and/or /d/, then [nd] cannot be the result of their concatenation. Cases of this kind in addition to Fijian include Kikongo (Welmers 1973, cited by Mwita 2007), San Miguel el Grande Mixtec (Iverson & Salmons 1996), and Tamabo (Riehl & Jauncey's 2005 Illustration of the IPA). In Tamabo the only voiced plosives are prenasalized (though plain nasals occur); Riehl (2008) notes that this is a common pattern in Oceanic languages, mentioning other languages with this distribution. Mixtec languages also show this pattern. Nonetheless, inventories with gaps appear to be less common than ones where prenasalized stops contrast with other stops (oral and nasal) (as can be seen in Appendix A in Stanton 2015, where examples of inventories without gaps include Gbeya (Samarin 1966) and Makaa (Heath 2003)).

More generally, prenasalized stops are often language-specific variants of voiced stop phonemes, with prenasalization aiding in the initiation and maintenance of voicing in stops (see e.g. Rothenberg 1968). Examples of prenasalized consonants alternating with voiced stops include Taiwanese (Pan 1994, Hsu & Jun 1998) and Greek (Arvaniti 1999, Arvaniti & Joseph 2000). Solé (2014) describes low-level but perceptible prenasalization in Spanish voiced stops. Conversely, as already seen for Japanese, voiced consonants can be reflexes of historical prenasalized consonants. Ratliff (2015) describes the various historical developments of original prenasalized consonants in the languages of Mainland South East Asia, noting that across languages these consonants are now variably ṆC, NC, ^{N}C, N^C or plain voiced C. Overall, then, there is a possible argument from correspondences: prenasalized consonants often correspond to voiced stops, which are clearly unitary segments. Similarly, they may correspond to nasal stops: DiCanio et al. (2018) describe an alternation in Yoloxóchitl Mixtec where NC is an allophone of N before oral vowels. Since N is a unit, its allophone NC is considered a unit as well.

In sum, prenasalized consonants in at least some languages behave phonetically and/or phonologically like single segments rather than like sequences, with nasalization preceding an oral interval, and they can contrast with nasals and/or voiced stops.

2.2 Preaspiration

Ladefoged & Maddieson (1996: 70) define preaspiration as 'a period of voicelessness at the end of the vowel, nasal or liquid preceding the onset of the stop closure'; similarly, Laver (1994: 356), 'early offset of normal voicing in the syllable-nuclear voiced segment, anticipating the voicelessness of the syllable-final voiceless segment'. Helgason (2002: iii) gives a slightly different definition that stresses the noise component of preaspiration: 'glottal friction at the juncture of a vowel and a consonant'. All of these definitions call attention to the necessity of a sonorant sound (often a vowel) before the preaspirated consonant.

Preaspiration is relatively rare in languages, with '2 UPSID languages, perhaps two dozen or so confirmed examples worldwide' (Clayton 2010: 1);[5] see also Hejná (2015),

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[5] Though a search of UPSID-451 using Henning Reetz's http://web.phonetik.uni-frankfurt.de/upsid.html yields only one language with preaspiration.

Clayton (2017). Postaspiration, in contrast, occurs in 26% of UPSID languages. Most of the discussion of preaspiration in the literature has centered on Nordic and other languages of northern Europe (Icelandic, Faroese, Swedish, Gaelic, Sámi), but it occurs elsewhere as well (see e.g. Silverman 2003 and Clayton 2017 for surveys). Silverman (2003) shows that what is called preaspiration is often something perceptually more salient, e.g. oral frication; here we will ignore this distinction.

2.2.1   Phonetics

While preaspirated fricatives occur (Hejná 2015), stops are more common and we focus on those here. It is commonly argued that preaspirated stops are sequences of two phonetic segments, [h] plus a stop. Hoole & Bombien (2010), Clayton (2010) and Hejná (2015), among others, review some arguments for this position: that the duration of the aspiration component is as great as the stop closure component, i.e. about two segments' total duration; that the phonetic properties, including duration and articulator gestures, of the aspiration component are like segmental [h]; and that the duration of the aspiration component is noticeably greater than the duration of postaspiration, so that the single-segment status of postaspirated stops does not carry over to preaspirated stops. Hoole & Bombien present evidence from Icelandic against the first two of these arguments: in their study, preaspiration was shorter than oral closure, and had different articulatory properties than [h]. NíChasaide (1985) and Ladefoged & Maddieson (1996) presented similar duration results from Lewis Gaelic; indeed, Nance & Stuart-Smith (2013) found systematic speaker variation, with younger Lewis speakers having even shorter preaspiration than older speakers. Thus, preaspiration can be shorter than an [h] segment and thus a preaspirated stop can be shorter than two segments.

With respect to comparisons of pre- and postaspiration, NíChasaide (1985) showed that while preaspiration is generally longer than postaspiration, preaspiration duration is so variable that in some languages/contexts the reverse is true (with the durations of preaspiration and postaspiration inversely correlated). Recently, Nance & Stuart-Smith (2013) showed just this pattern in Lewis Gaelic (see also Clayton 2010). While it is safe to say that the issue remains unsettled, the weight of recent phonetic evidence seems against the two-segments interpretation.

2.2.2   Phonology

The phonological status of preaspirated consonants as single vs. complex segments is mixed across languages. One argument for phonological unit segments is the common correspondence between preaspirated and postaspirated stops within a language. As Helgason (2002), Silverman (2003), Clayton (2010: 63–65) and Nance & Stuart-Smith (2013), among others, discuss, in many languages preaspirated consonants are positional allophones of an aspirated series. Preaspirated stops typically occur in medial and final positions, while postaspirated stops typically occur in initial position. Examples reviewed by Clayton include not only the Germanic languages and Gaelic, but also Halh Mongolian, Tarascan, Bora, and O'odham (where word-initial stops alternate depending on phrasal position). Since postaspirated stops are uncontroversially single segments, preaspirated stops must be too. Similarly, DiCanio (2012) describes preaspiration as a correlate of the fortis stops of Itunyoso Triqui, which are uncontroversially single segments.

A more delicate argument (e.g. NíChasaide 1985) comes from the fact that, as noted above, when a preaspirated stop follows a sonorant consonant, the sonorant is devoiced; there is no separate /h/ interval between the sonorant and the stop closure.

Finally, some languages exhibit morphophonemic alternations between unaspirated and preaspirated phonemes – alternations that, if the preaspirated consonants are not single segments, would require /h/ infixation in contexts where otherwise infixation is not posited (NíChasaide 1985, citing e.g. Árnason 1980).

On the other hand, in favor of /hC/ sequence analyses is the fact that preaspirates often pattern like (indeed, often derive from) geminates or CC sequences. (For a recent example, see Stevens & Reubold 2014.) Their distribution, favoring medial and final positions, is typical of geminates. One could argue that if geminates are sequences, then so are the corresponding preaspirates. In some languages, [h] now freely occurs before a variety of consonants as a result of phonological change, e.g. Spanish dialects with coda /s/ lenition (e.g. Lipski 1984, 1994; Torreira 2012), and Mazatec (Ladefoged & Maddieson 1996). Although the term preaspiration is often used for the resulting occurrences, most authors seem to agree that these are phonological sequences. A final argument for sequence status is that preaspirated stops never contrast completely minimally with either postaspirates or with CC sequences.

In sum, preaspirated consonants in at least some languages behave phonetically and/or phonologically more like single segments than like sequences, with aspiration preceding an oral closure. They generally do not contrast with, but instead are allophones of, postaspirated consonants.

2.3 Preglottalization

As Henton et al. (1992) note, the term 'glottalized' is ambiguous in the literature,[6] meaning either '[using the vocal cords] as an airstream initiator, as in glottalic ejectives' or 'preceded or followed by a glottal stop'. Here we exclude the glottalic meaning from consideration. Esling et al. (2005: 389) define a preglottalized consonant simply as one which is 'preceded by a glottal stop'. However, our usage here is perhaps broader, including laryngeal constrictions which do not produce a full occlusion (though they might be perceived as such).

In UPSID, 9% of the languages have 'laryngealization', which includes any preceding or simultaneous glottal stop or constriction in nonglottalic sonorants and obstruents. By comparison, 15% of UPSID languages have ejective stops.

2.3.1 Phonetics

Ladefoged & Maddieson (1996: 55) usefully distinguish two dimensions along which glottalized consonants can vary. First, the glottalization (glottal constriction) itself can vary from 'modified voicing' (e.g. creaky voice) to a full glottal stop.[7] Realizations along this continuum are influenced by such factors as speech rate and style (e.g. Redi & Shattuck-Hufnagel 2001, Pompino-Marschall & Żygis 2010) and prosody (e.g. Garellek 2014). Second, the timing of the onset of this glottalization relative to the oral constriction can vary from LEAD to SIMULTANEOUS to LAG, making glottalization different from nasalization or aspiration. Esling et al. (2005) divide the first dimension into 'laryngealized' (creaky voice) vs. 'glottalized' (full glottal stop, no creaky voice), and the second dimension into 'pre' vs. simultaneous. Thus they distinguish preglottalized, e.g. [ˀm], from preglottalized+ laryngealized, e.g. [ˀm̰], or prelaryngealized+laryngealized, e.g. [̰m̰], etc. An example of the latter would be Trique, where '[g]lottalization always precedes and overlaps the initial portion of the consonant' (DiCanio 2010: 232). Here we are concerned with any glottal constriction (whether full glottal stop or not) timed to fully or partially precede the oral constriction, i.e. both preglottalization and prelaryngealization in Esling et al.'s usage. (We will not discuss postglottalization here.)

Because glottalization can occur before, during, and after a primary articulation, its timing cannot always be specified as exclusively pre, simultaneous or post, and thus the

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[6] Also in Maddieson (2013).
[7] Such a distinction goes back to Li's (1943) 'Type 2' vs. 'Type 1' preglottalization, as cited by Esling et al. (2005).

situation with preglottalization is more complex than with prenasalization or preaspiration. Nonetheless, clear phonetic sequences have been documented. Esling and colleagues have used laryngoscopic imaging to demonstrate that in some languages a full glottal stop precedes an oral constriction. For example, Esling et al. (2005) show full ('moderate') glottal stops in the preglottalized resonants of Nuuchahnulth (a Wakashan language, also called Nootka), while Edmondson et al. (2004: 61) show that the preglottalized consonants of Sui (Tai-Kadai) are 'phonetically a moderate glottal stop followed by a voiced stop, a voiced nasal, a voiced approximant or a voiced fricative', without implosion or adjacent vowel laryngealization. Esling et al. (2005: 397ff.) also provide duration measurements, and show that Nuuchahnulth preglottalized resonants are almost twice as long as nonglottalized consonants and glottal stop. These cases thus seem to involve two phonetic segments, though they are treated as single segments phonologically (e.g. in the Carlson et al. (2001) Illustration of the IPA).

In contrast, if its glottal constriction overlaps extensively either with its oral constriction or with a preceding segment, a preglottalized consonant's duration may be like that of a simple single segment. For example, English voiceless stops often exhibit allophonic preglottalization, especially when in coda position. This is often called 'glottal reinforcement', e.g. Roach (1973) and references cited by Esling et al. (2005), MacMahon (2006) and Garellek (2010). Glottal reinforcement can be realized as laryngealization of the preceding vowel, without any lengthening of the stop interval, e.g. Huffman (2005). In Lai, glottalized (usually preglottalized) sonorants are much SHORTER than their plain counterparts (Roengpitya 1997, Plauché et al. 1998). Thus some preglottalized segments have durations consistent with single phonetic segments. It may be that when preglottalization involves a full glottal stop, then the duration is that of a sequence, but when it involves modified voicing, segment duration may be unaffected or even reduced.

Examples of languages where preglottalization varies between full glottal stop and laryngealization include Hupa (Athabaskan), where the glottalization associated with sonorants is often realized as creakiness rather than a full glottal stop, especially in the case of preglottalized sonorants (Gordon 1996: 167), and Yurok (Blevins 2003).

2.3.2 Phonology

Preglottalized consonants contrast with plain consonants in at least some languages. Anonby (2006), Baird (2002: 94) and DiCanio (2010) in their Illustrations of the IPA, give minimal and near-minimal pairs. Anonby's (near) minimal pair contrasts word-initial plain and preglottalized [w] and [j]. Baird gives Kéo minimal pairs contrasting plain vs. preglottalized (and prenasalized) versions of the same (obstruent) stops, for example /bala/ vs. /ˀbala/ vs. /mbala/. Baird (2002: 93) also notes that Kéo, 'a highly isolating language, with primarily monosyllabic and disyllabic words with basic (C)V((C)V) syllable structure', has no morphophonemic alternations, and 'very little allophony'; that is, the preglottalized consonants seem to be consistently preglottalized, not variable. DiCanio includes contrasts of /n/ vs. /ˀn/, /nd/ vs. /ˀnd/, /β/ vs. /ˀβ/, and /j/ vs. /ˀj/, among others. Nonetheless, in many languages preglottalized consonants are allophones of glottalized consonants that can also be postglottalized. Plauché et al. (1998) and Howe & Pulleyblank (2001) suggest that in languages with glottalized sonorants, these are always preglottalized in onsets but mostly postglottalized (sometimes preglottalized) in codas. Hupa (Gordon 1996) is another such a case, at least underlyingly.

Arguments that preglottalized consonants (whether phonemes or allophones) are phonologically single segments are often parallel to those made for prenasalized consonants. For example, Gordon (1996) argues for a single-segment analysis of the glottalized sonorants of Hupa on distributional grounds. First, if treated as clusters, glottal-stop+sonorant+obstruent sequences would be the only three-segment tautosyllabic clusters. Second, preglottalized

sonorants frequently occur stem-finally, and stem-final tautomorphemic clusters are very rare in Athabaskan. Similarly, Keller (2001) notes that in Brao-Krung, the preglottalized voiced stops form clusters with liquids just like single segments do, e.g. [bl] contrasts with [ˀbl], but there are no other three-segment clusters. DiCanio (2010) notes that, while preglottalized consonants have been analyzed as clusters in related dialects, in Itunyoso Trique, the distribution of preglottalized consonants is different from that of other clusters. For example, clusters are generally word-initial, but the preglottalized consonants occur only in onsets of word-final syllables, so generally word-medially. Stieng (Haupers 1969) and Halang (Cooper & Cooper 1966) are other languages in which such distributional arguments can be made.[8]

Another kind of argument is correspondence with segments that are clearly unitary. For example, in Kéo (Baird 2002), the preglottalized voiced stops 'correspond to implosives in cognate words' in related languages. Similarly, Wedekind (1990) notes in passing that while in Ethiopian languages the preglottalized sonorants tend to be analyzed as sequences, sometimes the preglottalized flap can be clearly related to implosive [ɗ]. In languages where preglottalized SONORANTS form a series with ejective STOPS, which are clearly single segments, the sonorants will likewise be considered unitary (e.g. Nuuchahnulth). And preglottalized allophones of clearly unitary segments, such as voiceless stops (e.g. English, Thai, Mah-Meri), will be considered unitary too.

Blevins (2003) gives several arguments for the unitary status of preglottalized sonorants in Yurok from phonological rules of the language that treat them, together with ejectives, as single segments (all, Blevins argues, with a glottal constriction feature). For example, if they were analyzed as clusters, then their behavior in neutralizations with plain sonorants would be unexpected: loss of glottalization would be the only case in the language of cluster simplification, and addition of glottalization would be the only case in the language of segment insertion.

In sum, preglottalized consonants in at least some languages behave phonetically and/or phonologically like single segments rather than like sequences, with (the onset of) glottalization preceding the primary oral constriction.

We have seen that the phenomena of prenasalization, preaspiration, and preglottalization have received significant treatments in the phonetic and phonological literature. We now turn to our proposals about how these can be represented within the IPA.

3 Proposal

3.1 Diacritics

The second principle of the IPA states that '[t]he IPA is intended to be a set of symbols for representing all the possible sounds of the world's languages', and the fifth principle clarifies this by noting that 'the use of symbols in representing the sounds of a particular language is usually guided by the principles of phonological contrast' (IPA 1999: 159–160). Taken together, these principles make it clear that if a sound is both phonetically attested and plausibly used as a phoneme in at least some languages, a standard symbol should be available to represent it. Prenasalization, preglottalization and preaspiration are all attested in multiple languages as properties of single unit phonemes, and in additional languages as allophones. We believe that enough evidence has accumulated to justify providing a single-segment notation for these phenomena. While experienced phoneticians are comfortable extending and innovating usage of existing diacritics and symbols, less experienced users appreciate greater

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[8] Though Cooper & Cooper (1966) decide on cluster analyses for preglottalization, postaspiration, and voiceless nasals – a rare instance of a preference for a small phoneme inventory.

coverage and exemplification on the chart. Below we provide suggestions for new diacritics and how they might fit into the IPA chart.

We propose three (sets of) superscript diacritics preceding a base symbol. We have seen that these are already commonly, though by no means universally, used by researchers, including in *JIPA*. Such diacritics are clearly interpretable and easily deployed by users.

For two of these cases, prenasalization and preaspiration, we can extend the usage of the existing diacritics for nasal release and aspiration, respectively, by explicitly endorsing their use in a new location. The existing Aspirated diacritic is shown on the current chart as [tʰ dʰ], in Unicode the 'modifier letter small h', U+02B0. The proposal for preaspiration is to use this same diacritic (the same Unicode character) BEFORE a base symbol. As there is no evidence that preaspiration occurs with voiced stops, the proposal is to show it only before a voiceless stop, e.g. [ʰt]. As noted in the 'Introduction' section above, this preaspiration diacritic is already part of the Extended IPA, and as such is listed in the 'Symbols for disordered speech' section of Appendix 3 of the *Handbook* (IPA 199: 193). For clarity, it might also be desirable to add the qualifier '(Post)' to the name of the diacritic now titled 'Aspirated' (thus distinguishing Preaspirated vs. (Post)aspirated).[9]

The existing Nasal release diacritic, introduced after the 1989 Kiel Convention, is shown on the current chart as [dⁿ], in Unicode the 'superscript Latin small letter n', U+207F. Prenasalization would be shown as [ⁿd]. There is then some ambiguity as to exactly how many/which superscript nasal diacritics are allowed – should the diacritic agree in place of articulation with the base symbol? This ambiguity already holds for the existing Nasal release diacritic: Neither on the chart nor in the *Handbook* is it specified whether [ᵐ], [ᵑ], etc. may be used to indicate homorganicity, though this is certainly common practice. We suggest that such homorganic usage be explicitly recognized and officially endorsed, for both nasal release and prenasalization, though not necessarily on the chart itself.[10] In Unicode, 'modifier letter small m', 'modifier letter small eng' and other nasal diacritics are already available in the Phonetic Extensions and Phonetic Extensions Supplement character sets.

In the case of preglottalization, there is no existing IPA glottal diacritic that can be re-purposed. However, like a few other non-IPA diacritics, it is already available in Unicode: 'modifier letter glottal stop', U+02C0. It could appear on the chart as [ʔt] and [ʔn], making clear that both obstruents and sonorants can be preglottalized. It would also be possible to extend our proposal to encompass postglottalization, that is, the same diacritic following a base symbol, though we will not pursue that possibility here.

3.2   Chart

As for how to fit these additions into the existing IPA Diacritics chart, we suggest that moving a few existing diacritics within the chart can free up the needed space. These suggestions are shown in the proposed chart in Figure 1. With these changes we not only create new space, but we bring some related diacritics together. To make room for 'Preaspirated' under Aspirated, we move the 'Rhoticity' diacritic with the other tongue blade diacritics. To make room for 'Preglottalized' under 'Creaky voiced', we move 'Linguolabial' also with the other tongue blade diacritics, under 'Dental'. Even with these additions to the third column of diacritics, 'Prenasalized' fits between 'Nasalized' and 'Nasal release'.

For maximum clarity, we have added throughout the Diacritics chart placeholders (small dashed circles) for the base symbols for all diacritics. Such placeholders are now

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[9] An alternative proposal re preaspiration, suggested by John Esling, is to have just one cell on the chart for Aspiration (pre- or post-), showing as examples [ʰt tʰ]. (He also suggests replacing [dʰ] in favor of [dɦ], thus adding a new diacritic [ɦ]. We like this proposal, too, but for the sake of simplicity, at this point we propose a minimum of new diacritics.)

[10] This could be made explicit in the chart by adding, e.g. bᵐ and ᵐb, respectively.

◌̥	Voiceless	n̥ d̥	◌̈	Breathy voiced	b̤ a̤	◌̪	Dental	t̪ d̪
◌̬	Voiced	s̬ t̬	◌̰	Creaky voiced	b̰ a̰	◌̼	Linguolabial	t̼ d̼
◌ʰ	(Post) Aspirated	tʰ dʰ	ˀ◌	Preglottalized	ˀt ˀn	◌̺	Apical	t̺ d̺
ʰ◌	Preaspirated	ʰt	◌ʷ	Labialized	tʷ dʷ	◌̻	Laminal	t̻ d̻
◌̹	More rounded	ɔ̹	◌ʲ	Palatalized	tʲ tʲ	◌˞	Rhoticity	ɚ a˞
◌̜	Less rounded	ɔ̜	◌ˠ	Velarized	tˠ dˠ	◌̃	Nasalized	ẽ
◌̟	Advanced	u̟	◌ˤ	Pharyngealized	tˤ dˤ	ⁿ◌	Prenasalized	ⁿd
◌̠	Retracted	e̠	◌̴	Velarized or pharyngealized	ɫ	◌ⁿ	Nasal release	dⁿ
◌̈	Centralized	ë	◌̘	Advanced Tongue Root	e̘	◌ˡ	Lateral release	dˡ
◌̽	Mid-centralized	ě	◌̙	Retracted Tongue Root	e̙	◌̚	No audible release	d̚
◌̩	Syllabic	n̩	◌̝	Raised	e̝ (ɹ̝ = voiced alveolar fricative)			
◌̯	Non-syllabic	e̯	◌̞	Lowered	e̞ (β̞ = voiced bilabial approximant)			

Figure 1 Proposed changes to IPA Diacritics chart.

commonly seen in online versions of the IPA chart, e.g. http://westonruter.github.io/ipa-chart/keyboard/, https://en.wikipedia.org/wiki/International_Phonetic_Alphabet#Diacritics_and_prosodic_notation, http://www.internationalphoneticalphabet.org/ipa-charts/diacritics/, and the Association's own clickable chart, currently at https://linguistics.ucla.edu/people/keating/IPA/inter_chart_2018/IPA_2018.html. We do not mean to suggest that the place-holder needs to be a dashed circle (a reviewer prefers a square), but we do suggest that using some overt placeholder is helpful for making clear the intended locations not only of our new diacritics, but of diacritics in general.

3.3 Discussion

Principle 4c includes the recommendation that diacritics be used 'when the introduction of a single diacritic obviates the necessity for designing a number of new symbols' (IPA 1999: 160). Since many different sounds can be prenasalized, preglottalized or preaspirated, the economy of diacritics is clearly preferable. It is true that use of a tie bar to represent these sounds (n͡d ʔ͡t h͡t) is also economical, and is an appropriate notation which we do not oppose. However, using the tie bar this way is itself also an informal extension of the IPA, as the chart refers only to its use for 'affricates and double articulations'. On balance, we believe that superscript diacritics are a better choice in the modern word-processing context, since tie bars often require special line-spacing adjustments in order to be legible.

We recognize that for prenasalization, the most common transcription in the literature seems to be a simple sequence (without tie bar). However, we believe that this is because of variation across languages in whether prenasalization forms a single segment or a cluster. As Cohn & Riehl (2012) showed, these variants can be distinguished acoustically. For clusters, NC sequence notation remains available, but for clear single segments, the diacritic offers an unambiguous transcription. More generally, differences in usage of the IPA will continue to arise from phonetic differences across languages, or from different interpretations of a given case, but our proposal extends the IPA options that are available for phonetic and phonological characterizations.

Another alternative for preglottalization seen in published research (e.g. Gordon 1996, Esling et al. 2005 for 'prelaryngealization') is an extension of the Creaky voiced combining diacritic into a free-standing diacritic that can precede the base symbol. When another

segment precedes the preglottalized segment, then the diacritic docks under it. Thus a preglottalized /t/ by itself could be notated as [ˀt], and that segment after an [a] would be [aˀt]. This notation represents the perceptual importance of the quality of voicing adjacent to a glottalized consonant. However, it is visually awkward, and loses the potential distinction between creaky voice on a vowel, and preglottalization of a consonant.

Finally, Blevins (2003) uses a preceding apostrophe for preglottalization (e.g. [ˀl], extending the use of this diacritic from ejectives. This notation represents in a clear way the equivalence between ejective obstruents and glottalized sonorants, extending the common orthographic use of apostrophe to represent glottal stop. (See also Carlson et al. 2001.) However, as a phonetic diacritic, it removes, or makes unclear, the meaning of apostrophe as involving not just glottal constriction but also a glottalic egressive airstream mechanism. It might also be visually confusable with the diacritic for primary stress.

Our proposal for preceding superscripts extends the IPA diacritic system to a new location. The *Handbook* (1999: 15) says only that '[d] iacritics are small letter-shaped symbols or other marks which can be added to a vowel or consonant symbol to modify or refine its meaning in various ways. A symbol and any diacritic or diacritics attached to it are regarded as a single (complex) symbol', without discussion of precisely where diacritics can be added. Adding the upper-left position for diacritics is not extreme, since the other three positions (above, below, upper-right) seem to form an incomplete set. However, some potential concerns are worth addressing.

First, our proposal allows a ternary structure to segments that is not currently expressible. Aspiration, glottalization or nasalization could begin a segment, and something else could end it. Our conclusion from the literature is that such notations are already in use; for example, in their Illustration of the IPA, Riehl & Jauncey (2005) give /ᵐbʷ/ as a single segment.

Second, might there ever be a parsing ambiguity as to whether a given diacritic is following vs. preceding its base symbol? Currently in the IPA, all superscript diacritics follow their base symbol, so there is no ambiguity. But under our proposal, could a sequence like e.g. [pʰp] arise, in which the affiliation of the [ʰ] is not clear because the language has both postaspiration and preaspiration? We have seen no such cases for preaspiration or prenasalization, but, for those researchers who use [ˀ] for both preglottalization and postglottalization, ambiguous sequences are indeed possible, due to the common pattern of preglottalization in onsets but postglottalization in codas (e.g. Plauché et al. 1998). Word-medially, a [ˀ] could represent either of these allophones. For example, Plauché et al. (p. 385) list the Yowlumne word [tsʼolˀlol] as an example of coda glottalization ([lˀ]), but the sequence appears consistent with onset glottalization ([ˀl]) as well (though all of their examples show onset consonants following vowels, not consonants). However, for any such ambiguous cases, the IPA Syllable boundary diacritic can be used to make the parse clear, e.g. [tsʼolˀ.lol]. It is also true that if the inventory of the language is not known to a reader, the interpretation of a given diacritic could be unclear. For example, Esling et al. (2005: 406) give a Nuuchahnulth word with the sequence [mˀj]. With the knowledge that this language has preglottalization but not postglottalization, the sequence is clear. Again, the syllable boundary diacritic could be used here for maximum clarity.

Finally, if these new diacritics represent specifically initial events within a segment, are the interpretations of existing diacritics implicitly changed? Must we now understand diacritics that follow their base symbol to refer exclusively to events at the end of a segment? In our view, no: only diacritics with 'pre', 'post' or 'release' in their names would have a limited temporal interpretation. The other diacritics would remain ambiguous as they are now. Indeed, no IPA transcription is intended to make detailed claims about timing, and all diacritics will continue to be used for a variety of articulations that are not necessarily clearly limited to a specific short time interval. The addition of new diacritics to the chart simply increases the resources available to the transcriber. It would of course be possible to re-define other existing diacritics to have more specific temporal interpretations, making it desirable

to distinguish 'pre' vs. 'post' uses for these as well. Such extensions are doubtless already seen in the literature. However, such possibilities are well beyond our goal in this proposal, which is to address these most common, seemingly almost standard, instances of preceding diacritics.

4 Conclusion

In conclusion, we propose that the Association consider the introduction of three new superscript diacritics preceding their base symbol to indicate preaspiration, preglottalization, and prenasalization. The diacritic for preaspiration is already available in the ExtIPA and is derived from the existing diacritic for postaspiration; the diacritic for prenasalization is derived from the existing diacritic for nasal release; the diacritic for preglottalization is new, derived from the glottal stop symbol. All three diacritics are already available in Unicode-compliant character sets. We have suggested how the current chart of IPA diacritics could be revised to accommodate these additions.

Acknowledgements

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