Received: 4 February 2020 | Revised: 11 September 2020 | Accepted: 15 September 2020

DOI: 10.1002/wcs.1547

OVERVIEW

WIREs COGNITIVE SCIENCE WILEY

The versatility of creaky phonation: Segmental, prosodic, and sociolinguistic uses in the world's languages

Lisa Davidson

Department of Linguistics, New York University, New York, New York

Correspondence
Lisa Davidson, Department of Linguistics, New York University, New York, NY.
Email: lisa.davidson@nyu.edu

Abstract

Creaky phonation (also known as creaky voice, vocal fry, laryngealization, or glottalization) is a voice quality that refers to shortened and thickened vocal folds that vibrate at a low and quasi-regular fundamental frequency with a long period of damping. Cross-linguistically, creaky phonation can span either short or long domains. When implemented on individual vowels or consonants (as in Zapotec or Montana Salish), it can signal phonemic contrast with other voice qualities, or it can be an additional acoustic cue to enhance other contrasts, such as tone (as in Mandarin or Cantonese). Another segmental use of creaky phonation in many languages is as a variant of glottal stop. Creaky phonation can also be implemented as a prosodic element that signals the end of a phrase (as in English or Mandarin), or indicates relinquishing a conversational turn (as in Finnish). It can also express meaning in a social interaction, such as irritation (in Vietnamese). Lastly, creaky phonation can be deployed as a sociolinguistic marker to establish identities, convey affect, or distinguish one speech group from another within the same language. In some social circumstances, such as the perception that young women use creaky phonation at greater rates than men do, it can be evaluated negatively by listeners. As creaky phonation can be combined with linguistic elements at various levels and is easily perceptible, it has taken on a remarkable number of roles in our linguistic repertoires.

This article is categorized under:
Linguistics > Language in Mind and Brain

KEYWORDS

creaky phonation, phonetics, prosody, sociolinguistics, voice quality

1 | INTRODUCTION

As a linguistic property, creaky phonation plays many roles. One function of creaky phonation is to indicate segmental phonological contrasts, whether as an implementation of glottal stops, as a voice quality on vowels and/or consonants (sometimes in contrast with modal, breathy, lax, or other qualities), or as a component of tone and register contrasts in languages that combine phoneme distinctions via fundamental frequency (F0), length, vowel quality, and voice quality. Another way in which creaky phonation is deployed is for prosodic purposes, whether to mark a phrasal boundary or as a prosodic cue to indicate a particular meaning. Creaky phonation also has been identified as a sociolinguistic marker, sometimes to convey a particular affect, or used by speakers to signal inclusion with a particular group of speakers.

This review is a synthesis of the research that has been carried out on the myriad implementations and uses of creaky phonation for linguistic purposes. For this article, the term "creaky phonation" is an umbrella term meant to include the other labels that have been used to refer to the acoustic and articulatory properties of creakiness: creak, vocal fry, glottal fry, glottalization, and laryngealization. (For some discussions about how these terms have been used distinctively, see Garellek (2013), Gordon and Ladefoged (2001), Henton, Ladefoged, and Maddieson (1992), Keating, Garellek, and Kreiman (2015), Laver (1980), and Michaud (2004).) Where relevant, individual terms will be explained in more detail. Acoustically, creaky phonation is distinguished by its low fundamental frequency (approximately the 40–90 Hz range) and long period of damping between one glottal pulse and another. Articulatorily, creaky voice is often described as having a long closed phase in the glottal cycle, with thickened and shortened vocal folds. However, creaky phonation is not a monolithic collection of phonetic properties, and the variability that has been observed will be further explained in the next section.

2 | ARTICULATORY AND ACOUSTIC PROPERTIES OF CREAKY PHONATION

Creaky phonation as a "physiological normal mode of laryngeal operation" (Hollien, Moore, Wendahl, & Michel, 1966), as opposed to a pathological voice type, has been discussed in the literature since the 1960s (Catford, 1964; Hollien, 1974; Hollien & Michel, 1968; Hollien & Wendahl, 1968; Laver, 1980). Articulatory descriptions have been relatively consistent since that time, with studies showing a long period between successive glottal openings (low F0), low airflow (Childers & Lee, 1991; Esling, 1984; Kreiman & Sidtis, 2011; Murry & Brown, 1971; Ni Chasaide & Gobl, 1997), and low open quotient (the closed phase during the glottal cycle is longer than the open phase), as shown by electroglottography (DiCanio, 2009; Epstein, 2002; Garellek, 2014; Michaud, 2004; Ni Chasaide & Gobl, 1997). As for the laryngeal articulators, Hollien et al. (1966) was an early source noting that the vocal folds are adducted and thick for creaky phonation, and that the ventricular folds are also adducted and may be coming into contact with the vocal folds (also referred to as "ventricular incursion"), which has been corroborated by more recent studies (Edmonson & Esling, 2006; Esling, Moisik, Benner, & Crevier-Buchman, 2019; Garellek, 2013; Moisik, Esling, Crevier-Buchman, Amelot, & Halimi, 2015). Esling et al. (2019) argue that the ventricular folds have the effect of increasing the effective vibrating mass, which lowers F0, adds damping, which may make the vibration more likely to slow down and cease, and adds increased degrees of freedom, which leads to irregularity in the vibration during creaky phonation. For detailed accounts and reviews of the laryngeal structures and musculature relevant to creaky phonation, see Edmonson and Esling (2006), Esling et al. (2019), Hirose (1997), and Kreiman and Sidtis (2011).

These articulatory descriptions are reinforced by a variety of acoustic measurements that have been used in the linguistic literature to examine how creaky phonation differs from modal phonation and other types of non-modal phonation. Much of this work is summarized in Kreiman, Gerratt, Garellek, Samlan, and Zhang (2014) and Garellek (2019), who lay out a psychoacoustic model of voice quality which contains four major components: harmonic source spectral slope, inharmonic source noise, time-varying source characteristics, and the vocal tract transfer function. For spectral tilt in creaky phonation, low $H1 - H2$ (the amplitude of the first harmonic minus the amplitude of the second harmonic) relative to modal vowels has been shown to be a reliable acoustic correlate of the vocal fold constriction that characterizes most creaky phonation (Andruski & Ratliff, 2000; Blankenship, 2002; Brunelle & Finkeldey, 2011; Davidson, 2019a; DiCanio, 2012; Garellek, 2015; Garellek & Keating, 2011; Miller, 2007). In some languages, other spectral tilt measures may also distinguish creaky from modal phonation, such as $H1 - A3$ (the amplitude of the first harmonic minus the amplitude of the harmonic closest to F3) in Itunyoso Trique (DiCanio, 2012), $H1 - A2$ (the amplitude of the first harmonic minus the amplitude of the harmonic closest to F2) in Jalapa Mazatec (Garellek & Keating, 2011), or $H2 - H4$ (the amplitude of the first harmonic minus the amplitude of the fourth harmonic) in American English (Garellek & Seyfarth, 2016). Some harmonics used in spectral tilt measurements are illustrated in Figure 1. As for inharmonic noise, measures such as cepstral peak prominence, harmonics-to-noise ratio (HNR), and jitter have shown that creaky voice is usually less periodic than modal voice (Blankenship, 2002; Davidson, 2019a; Garellek, 2012; Garellek & Keating, 2011; Kuang & Liberman, 2016). One consideration regarding measures relying on F0 is that if creaky phonation causes the fundamental frequency to be too aperiodic to be accurately tracked, then it is not possible to correctly

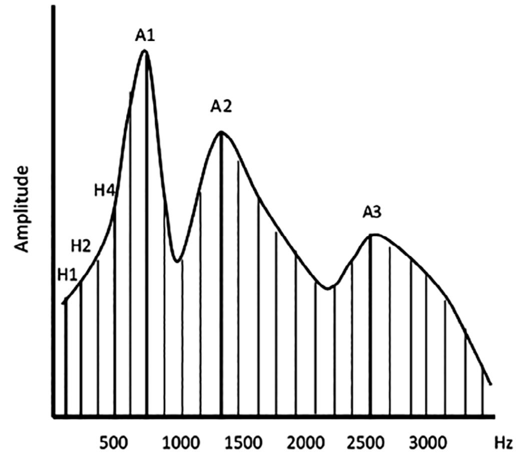

FIGURE 1 Illustration of some harmonics that are used in spectral tilt measures. "H" refers to the first, second, fourth (etc.) harmonic, and "A" refers to the amplitude of the harmonic closest to the first, second, and third formants

estimate spectral tilt or noise measures that are based on harmonics. A consequence of this is that researchers may eliminate tokens (or portions of tokens) of creaky phonation where F0 cannot be calculated, which means that the acoustic properties of creaky phonation are not always fully captured within these measures. Researchers could acknowledge this problem by reporting how much of their data was eliminated from spectral tilt or noise measurements due to difficulties tracking F0.

Fundamental frequency has been identified as one of the most salient acoustic cues distinguishing creaky from modal phonation. Where there is enough periodicity in the signal that it can be accurately measured, it is almost always reported that creaky phonation has a particularly low F0, usually below 100 Hz (Hollien & Michel, 1968; Hollien & Wendahl, 1968; McGlone, 1967; McGlone & Shipp, 1971; Murry, 1971). Synthesizing their own results and a survey of the literature, Blomgren, Chen, Ng, and Gilbert (1998) report that creaky phonation has a typical range of about 20–70 Hz, with the lowest reported frequency at 10.9 Hz (McGlone, 1967) and the highest at 92 Hz (Murry, 1971). An interesting finding based mainly on American English is that the average F0 range of creaky voice produced by male and female speakers does not differ, though the average F0 ranges for modal phonation are approximately 100–140 Hz for males and 170–240 Hz for females (Blomgren et al., 1998; Pepiot, 2014). Keating and Kuo (2012), who have their participants read a passage, demonstrate that both male and female American speakers can have more extended ranges (though the lower bound for creaky F0 remains similar): 46–220 Hz for males (average 107 Hz) and 59–357 Hz for females (average 195 Hz).

Phonetic work has also suggested that creaky phonation is not a monolithic phenomenon, and that there may be a variety of different acoustic and articulatory properties that can be implemented when creaky phonation is needed (Abdelli-Beruh, Drugman, & Red Owl, 2016; Drugman, Kane, & Gobl, 2014; Gerratt & Kreiman, 2001; Ishi, Sakakibara, Ishiguro, & Hagita, 2008; Keating et al., 2015). A useful summary of the different types of creaky phonation that have been reported in the literature is found in Keating et al. (2015). Prototypical creaky phonation (nb: Keating et al. use "creaky voice" instead of "phonation") refers to "(a) low rate of vocal fold vibration (F0), (b) irregular F0, and (c) constricted glottis: a small peak glottal opening, long closed phase, and low glottal airflow." Vocal fry is similar to prototypical creaky phonation except that it is more regular, though it still has damped pulses. Multiply pulsed creaky phonation is characterized by alternating longer and shorter pulses that are also higher and lower in amplitude (Batliner, Burger, Johne, & Kiessling, 1993; Davidson, 2019b; Hollien & Wendahl, 1968; Ishi et al., 2008; Redi & Shattuck-Hufnagel, 2001). Aperiodic voice refers to vocal fold vibration that is so irregular that there is no apparent periodicity, and nonconstricted creaky phonation has been found to occur when the glottis is opening and subglottal pressure is naturally low, as in the end of a sentence, but F0 is low and glottal pulses are irregular (Slifka, 2000, 2006). Prototypical creak, vocal fry, multiply pulsed creak, and aperiodic creak are illustrated for American English in Figure 2. Where relevant, these different types will be referenced in the following sections.

Having reviewed some of the articulatory and acoustic characteristics of creaky phonation, we now turn to linguistics uses of creak, starting with creaky phonation as an element that functions as segmental contrast.

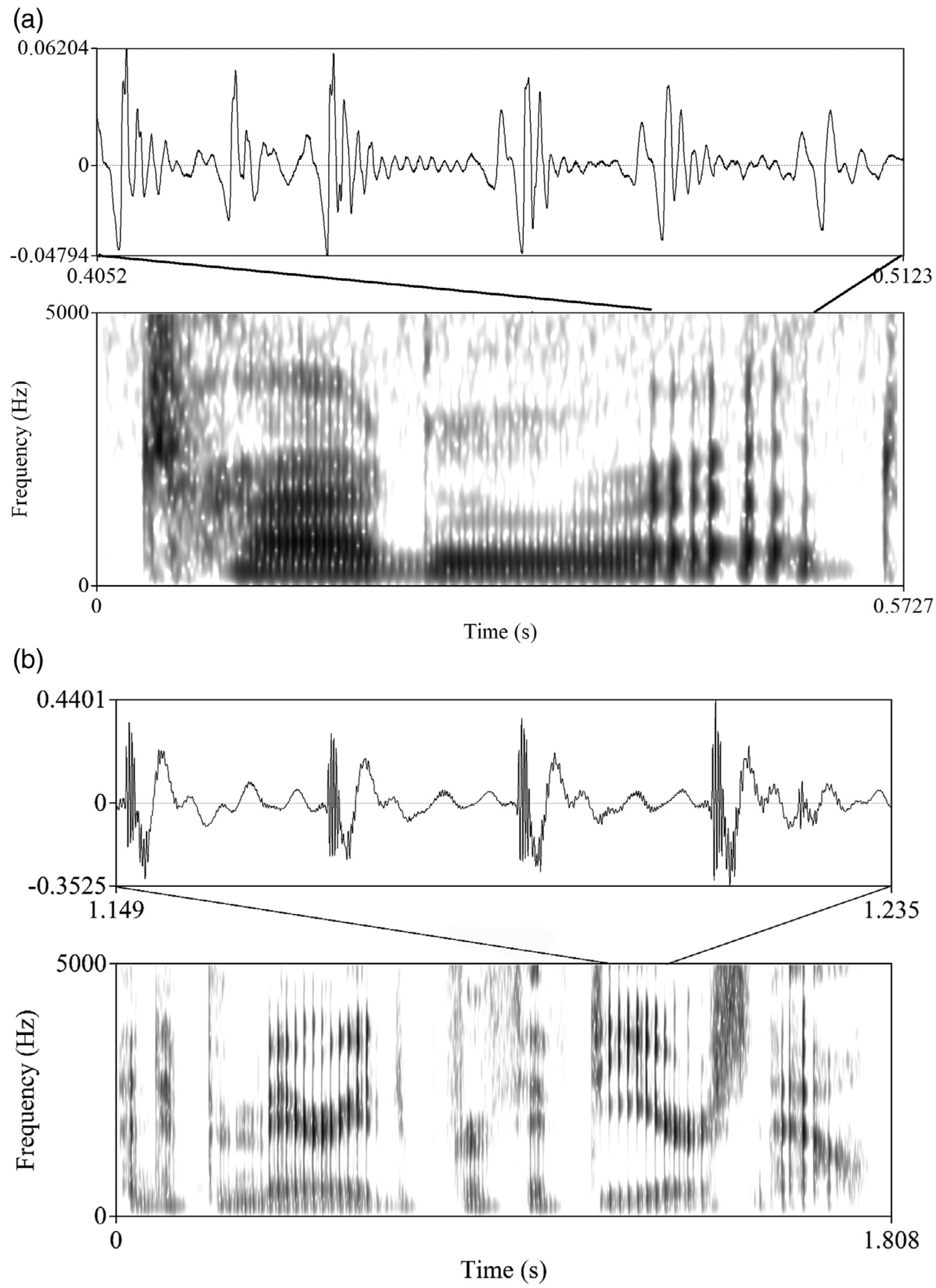

FIGURE 2 Examples of creak types in English phrases and sentence. The waveform corresponds to the segments marked with underlining in the caption; lines between the images indicate where in the spectrogram the waveform comes from. While individual utterances may contain more than one type of creaky phonation, the type of creaky phonation that was observed (based on Keating et al., 2015) in the underlined segments is noted in the caption for each image. Italics in the transcription indicate the words that are produced with creaky phonation. (a) "trodden road." Prototypical creak. (b) "and have been married for 50 years now." Vocal fry. (c) "I can't do that anymore." Aperiodic. (d) "was their doing entirely." Multiply pulsed

3 | CONTRASTIVE CREAKY PHONATION IN CONSONANTS AND VOWELS

In this section, the focus is primarily on phenomena where creaky phonation is attributed to a segmental or contrastive difference, whether as the instantiation of glottal stop, or as a non-modal phonation on a vowel series in contrast with modal vowels. It should be noted that creaky phonation can accompany other sounds as a secondary articulation, as in ejectives, implosives, pharyngeal, or epiglottals (Esling & Harris, 2005; Ladefoged & Maddieson, 1996), but these are

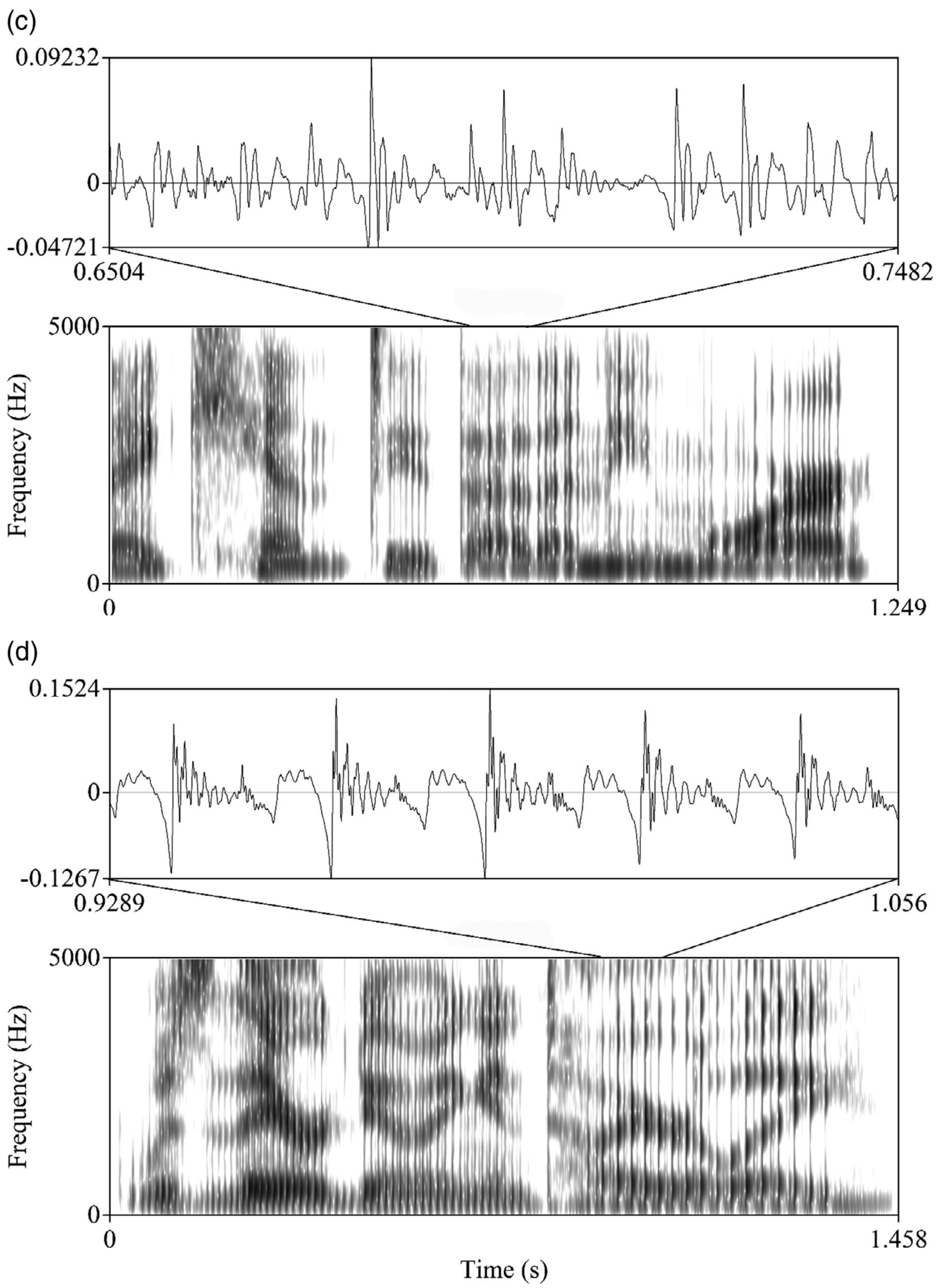

FIGURE 2 (Continued)

beyond the scope of this paper. Moreover, the following discussions are meant to introduce various types of glottal stops and creaky phonation on consonants and vowels that have been studied, but are not exhaustive.

3.1 | Glottal stops

On the surface, it might be expected that a phonemic glottal stop in a language would be produced most often as a period of silence, perhaps with some evidence of coarticulatory creaky phonation on surrounding sonorant and vowel sounds. Articulatory descriptions of full glottal stops describe this sound as a complete adduction of the vocal folds to ensure that air cannot pass through the glottis (Edmonson & Esling, 2006; Esling et al., 2019; Gordon & Ladefoged, 2001; Ladefoged & Johnson, 2014; Laver, 1994). Laryngeal imaging data have shown that similar to creaky phonation, the ventricular folds also play a role in helping to stop vocal fold vibration by pressing down on them like brake pads (Edmonson & Esling, 2006; Esling et al., 2019; Esling & Harris, 2005; Garellek, 2013). Esling et al. (2019) distinguish between two different glottal configurations—vocal fold adduction alone, and ventricular fold incursion—as "weaker" and "stronger" variants of glottal stop. For example, full glottal stops in Nuu-chah-nulth require more than just vocal fold adduction, and are produced with "completely adducted vocal folds at the vocal processes of the arytenoids, partially adducted ventricular folds, and moderate constriction of the supraglottic tube" (Esling, Fraser, & Harris, 2005).

Yet, despite the relative intuitiveness of this articulatory mechanism for glottal stop, speakers of languages said to have phonemic glottal stop often do not produce them with a full closure. As Ladefoged and Maddieson (1996) write, "In the great majority of languages we have heard, glottal stops are apt to fall short of complete closure, especially in intervocalic positions. (p. 75)" While there is some debate for some languages as to whether a period of intervocalic creaky phonation should be attributed to a glottal stop or voice quality on a vowel given the low incidence of full closure (e.g., Yucatec Maya in Frazier, 2013; Coatzospan Mixtec in Gerfen & Baker, 2005), other phonetic descriptions of glottal stops in typologically distinct languages show that many researchers still report that full glottal stops are rare. Quick (2003) reports that full glottal stops can be observed in Pendau, a Western Malayo-Polynesian language, but the most common instantiation is creaky phonation either between two vowels or at the edge of the vowel that it precedes. Priestly (1976) makes similar comments for Carinthian Slovene. In the Oto-Manguean language Itunyoso Trique, which allows glottal stops both word finally after a vowel and intervocalically, they are typically produced as a period of creaky phonation, without full glottal closure (DiCanio, 2012), though a full glottal stop may be more common in pre-pausal positions. Bennett (2016) also notes that glottal stop in Mayan languages such as K'ichee' and Q'anjob'al can have a full closure, especially in word-final position, but that most often it is realized as creaky phonation induced on adjacent vowels. Examining running speech in Arapaho (Algonquian), Whalen, DiCanio, Geissler, and King (2016) found that only about a quarter of phonemic glottal stops were produced with full closure. Examples of a full glottal stop and a modal-creaky phonation-modal sequence both representing glottal stop in Hawaiian are show in Figure 3 (examples from Kimura, 2020).

On the other hand, there is some evidence that full closure realizations may be more common in at least some languages. For example, Maltese is analyzed as having both phonetic glottal stops and optional epenthetic glottal stops that can occur before vowel-initial words (Galea, 2016). In a task designed to elicit glottal stops either intervocalically or after an /m/, Mitterer, Kim, and Cho (2019) found that a little over 60% of underlying glottal stops were produced with full closure, whereas a little under 60% of epenthetic glottal stops had full closure. Harris (2001) describes syllable-final phonemic glottal stops in Thai as having a "moderate" closure, with fiberoptic laryngoscope imaging indicating constriction of the whole laryngeal vestibule. Harris's comment that final glottal stops seem to be dropped in unemphatic speech suggests that a full closure is not always required in Thai, however.

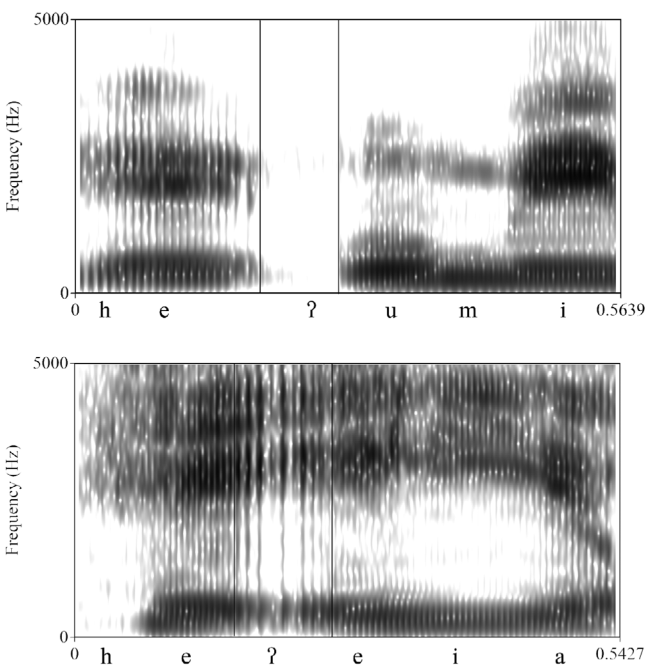

FIGURE 3 Glottal stops in Hawaiian. (Top) [he ʔumi] *he 'umi (mākou)* "we are ten," with a full glottal stop (Bottom) [heʔeia] *He'eia* (place name on O'ahu), produced as a sequence of modal–creaky–modal phonation

The relatively large literature on glottal stops in English and German makes the case that for some languages the implementation of glottal stop can depend on factors such as stress, prosodic boundary, or speech rate. In these languages, unlike most of the languages just mentioned, glottal stop is not a contrastive phoneme, but rather appears in certain positions epenthetically or allophonically, as in word-initial position when a word begins with a vowel, as hiatus resolution, or in American English, as an allophone of /t/ before syllabic nasal (e.g., *button* [bʌʔn̩]). Garellek (2013) finds that in extremely formal speech, such as the production of sequences like [ʔi ʔi ʔi], speakers implemented a full glottal stop nearly 70% of the time. When the strength of the boundary before a vowel-initial word like *Emma* was manipulated, Pierrehumbert and Talkin (1992) reported that the percentage of tokens with "noticeable /ʔ/" was greatest when it was at a sentence boundary in read speech as compared to in phrase-medial position, whether accented or deaccented. Most other analyses of phrasal prominence in English refer primarily to creaky phonation, as opposed to full glottal stop. Dilley, Shattuck-Hufnagel, and Ostendorf (1996) found in the speech of radio announcers that creaky phonation on vowel-initial words is much more likely at the beginning of an intonational phrase than in the middle of one. Full vowels were also more likely to be produced with creaky phonation than reduced vowels were. Garellek's (2014) examination of English and Spanish confirms that glottalization appears to be associated with prominent initial vowels. Davidson and Erker (2014) examined vowel–vowel hiatus both within words and across word boundaries and found that some implementation of creaky phonation was much more likely across word boundaries (e.g., "see otters") than within words (e.g., "kiosk"), but that full glottal stops were only produced in 17% of the overall responses. The remaining responses were either modal–creaky–modal sequences, creaky phonation on V1 or V2, or creaky phonation on the whole sequence. Full glottal stops were also more likely when they preceded stressed vowels.

German has also been reported to show epenthetic glottal stops preceding vowel-initial words (Alber, 2001; Kohler, 1994), and like English, they are more often realized as periods of creaky phonation than as full glottal stops. Kohler (1994) found in a corpus of read sentences that when vowel-initial words were produced with some kind of creaky phonation, only 15% had full closure. When full closure did occur, it was more likely preceding a stressed vowel than an unstressed one. Pompino-Marschall and Zygis (2011) demonstrate that speech rate has a salient effect on the realization of glottal stops before vowel-initial words in speeches: at the slowest rate (of four), full glottal stops occurred nearly 50% of the time, but the proportion of creaky phonation and especially the proportion of modal phonation rose quickly after that. Their results also indicate that vowel-initial content words are more likely to be marked with a full glottal stop at the slowest rate than function words are.

A comparison of languages with phonemic glottal stop to those which are said to have epenthetic glottal stops suggests that speakers' targets, whether full glottal stop or creaky phonation, may depend on which type of glottal stop the language has. While data from more languages are still necessary, one speculation is that the target of phonemic glottal stops could be a full stop, but widespread lenition processes similar to those reported for other stops in myriad languages could result in the glottal stop being produced as less constricted creaky phonation (e.g., Cohen Priva & Gleason, 2020; Gurevich, 2011; Katz, 2016; Kingston, 2007; Kirchner, 2004; Lavoie, 2001). On the other hand, languages that realize glottal stop/creaky phonation at phrase edges and word boundaries suggest that the articulation is a reflection of the strength or importance of the boundary (e.g., Cho & Keating, 2001; Fougeron, 2001; Fougeron & Keating, 1997; Keating, Cho, Fougeron, & Hsu, 2003). The higher the prosodic boundary, the more likely that epenthesis of a glottal element will be a full glottal stop, as an indicator of a domain-strengthening process (Umeda, 1978). Similarly, in the case of hiatus resolution, creaky phonation (which strengthens to glottal stop before stressed syllables) may help listeners with word segmentation, since it almost never occurs within words and primarily across word boundaries.

3.2 | Contrastive creaky phonation on vowels and consonants

While glottal stops are a possible phoneme or allophone in some languages, another role for creak is as a phonation realized on a vowel or sonorant that is contrastive with modal phonation, or other non-modal phonations such as breathy voice. The precise way in which languages implement creaky phonation differs from language to language, and in many languages, non-modal phonation covaries with tone to create lexical contrast. Researchers who have studied these contrasts often prefer particular terms to describe the specific type of creaky/laryngealized/glottalized phonation found in each language, but those details will not be surveyed here, and the term "creaky phonation" will continue to be used as an umbrella term.

Many languages realize non-modal phonation contrasts on vowels, often in conjunction with tone. One of the main research questions regarding the implementation of non-modal phonation like creak is how it is timed within the vowel (see a review in Gordon & Ladefoged, 2001). On the basis of several typologically unrelated languages, Silverman (1995/1997) proposes that vowel quality, phonation, and tone are sequenced within languages in order to ensure that all of these elements can be perceptually recovered. Jalapa Mazatec is a well-studied case in which the phonation contrasts and tone can combine freely, and which has creaky phonation as one voice quality type, along with modal and breathy (Blankenship, 2002; Garellek & Keating, 2011; Silverman, Blankenship, Kirk, & Ladefoged, 1995). Phonation types are most distinct in the first third of the vowel, diminished but still present in the second third, and least prominent in the last third. In Mazatec, a vowel's tone category does not have an effect on the spectral tilt or noise acoustic measurements for voice quality. Creaky phonation is localized to the end of the vowel in Santa Ana del Valle Zapotec (Esposito, 2003). This is also shown in the example of Tlacolulita Zapotec in Figure 4 (examples from the UCLA Phonetics Lab Archive, http://archive.phonetics.ucla.edu/). In Comaltepec Chinantec, which also has tone and creaky phonation on the vowel, the creaky portion can either precede or follow the tone on the modal portion (Silverman, 1997). Yaláleg Zapotec has a three-way tone contrast, all of which can also have creaky phonation. Avelino (2010) uses acoustic and electroglottographic evidence to demonstrate that creaky vowels have modal phonation on the first half, or are produced as modal–creaky–modal, which ensures that tone and vowel quality are perceptible on at least the first half of the vowel.

In some languages, such as Yucatec Maya and K'ichee', the modal–creaky–modal pattern has led some Mayanists to refer to these articulations as "rearticulated vowels" or "broken glottal vowels" (Bennett, 2016), but acoustic analysis suggests that these vowels can be analyzed as having creaky phonation timed at the middle of the vowel, as opposed to one of the edges (Frazier, 2013). In K'ichee', the vowel is actually more likely to be produced with a full glottal stop rather than creaky phonation (Baird, 2011). While some kind of sequencing between creaky and modal phonation is the norm within these vowels, there have been reports of at least some languages where creaky phonation may extend throughout the whole vowel duration. For example, White Hmong has tone, and creaky phonation on the low tone contrasts with a breathy phonation on a falling tone, but Garellek (2012) found that the acoustic correlates of creakiness, especially H1 − H2 and HNR, persist through almost the whole vowel interval.

While non-modal phonation and tone can combine almost independently in some of the languages just discussed, many Southeast Asian languages implement what has been called *register*, which has been described as "the redundant use of pitch, voice quality, vowel quality, and durational differences to distinguish (typically two) contrastive categories" (Brunelle & Kirby, 2016, p. 193). While not all authors always agree on whether tone, phonation or other properties should be given equal consideration in determining register contrasts, it is clear that phonetic properties cooccur in these languages to create phonemic contrast. Languages that have two registers often group properties together, as in Eastern Cham, which has a higher register consisting of high pitch, modal phonation, lower vowels, and shorter durations, and a low register that is characterized by low pitch, breathy phonation, higher vowels, and longer duration (Brunelle, 2005).

Other languages have yet more complex patterns as compared to a clear two register distinction. In Northern and Hanoi Vietnamese, electroglottographic and laryngoscopic data show that of tone types in the language, some show no laryngealization or creaky phonation at all, while others are accompanied by creaky phonation that is either at the end

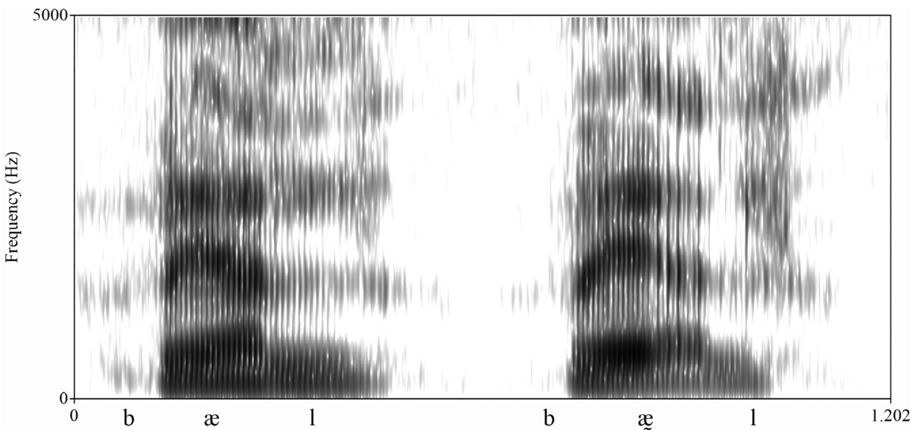

FIGURE 4 Examples of vowels in Tlacolulita Zapotec with modal phonation (left, [bæ ˥] "fish") and creaky phonation on the last half of the vowel (right, [bǽ̰l], "snake")

of the vowel or in the middle, especially when followed by a rise in the tone at the end of the syllable (Brunelle, Nguyên, & Nguyên, 2010; Kirby, 2010; Michaud, 2004). Crucially, creaky phonation is tied to specific tones and does not fully cross with them. Kuang (2013) describes Black Miao as having five level tones, where the distinctiveness of the tones is enhanced by voice quality contrasts: the lowest tone has creaky phonation, tones 22 and 44 are modal but tone 33 is breathy, and the highest tone has tense phonation (in this case, high F0 but a greater portion of each glottal cycle is produced with closed vocal folds). In Takhian Thong Chong, the registers have been labeled as modal, tense, breathy, and breathy-tense. Tense, also called "pressed," is a type of laryngealized phonation that DiCanio (2009) describes as more periodic than the typically irregular pulses of creaky phonation. There is some evidence that these phonation types are reinforced by particular vowel qualities (e.g., modal and tense vowels tend to be lower than breathy or breathy-tense), F0 and duration.

Another case of creaky phonation requiring certain phonetic conditions to be realized is the Danish stød (Fischer-Jørgensen, 1989; Grønnum & Basbøll, 2007; Grønnum, Vazquez-Larruscaín, & Basbøll, 2013). Stød is often considered a suprasegmental phonological element that in its canonical realization, is implemented as creaky phonation with a brief F0 dip on syllables that have a heavy enough rime (e.g., long vowels or vowel-sonorant rimes). The location of the stød's creaky phonation in the rime can be very variable, though it does not usually span the entire long vowel or vowel-sonorant sequence. Lastly, while Mandarin and Cantonese are not referred to as register languages, they are examples of languages where phonation is a secondary cue to an otherwise F0-based tone system. Mandarin tone 3 and Cantonese tone 4 are often accompanied by creaky voice in the latter portion of the vowel (Belotel-Grenie & Grenie, 1997; Belotel-Grenie & Grenie, 2004; Yu & Lam, 2014), though Kuang (2017, 2018) shows that Mandarin speakers can use creaky phonation whenever they are implementing a low pitch target even on other tones, such as tone 4.

A question of the timing of non-modal phonation arises for sonorant consonants just as it does for vowels. In their overview of non-modal phonation types, Gordon and Ladefoged (2001) identify Northwest American languages such as Kwakw'ala, Montana Salish, Hupa, and Kashaya Pomo as having glottalized sonorants that contrast with modal ones. Detailed work on Athabaskan languages suggests that there are two main patterns for glottalized sonorants: preglottalized, in which the creaky phonation is produced simultaneous with the onset of the consonant and extends for some duration, but not the whole consonant, and postglottalized, in which the creaky phonation begins somewhere in the middle of the consonant and can extend into a following sound (Hargus, 2016; Howe & Pulleyblank, 2001; Ladefoged & Maddieson, 1996; Silverman, 1995/1997). An example of a preglottalized nasal in Montana Salish is shown in Figure 5 (from the UCLA Phonetics Lab Archive, http://archive.phonetics.ucla.edu/). For consonants, the location of creaky phonation is not only language dependent, but may also depend on whether the sonorant is in onset or coda position. If there is an asymmetry, then onset position tends to be preglottalized (Yowlumne, Nuu-chah-nulth, Coatlán Loxicha Zapotec) while coda position tends to be postglottalized (Yowlumne, Kashaya, Coatlán Loxicha Zapotec) (Howe & Pulleyblank, 2001; Plauché, Beam de Azcona, Roengpitya, & Weigel, 1998). Howe and Pulleyblank argue that this is the opposite of what would be expected if laryngeal cues were being phonetically maximized, since, for example, preglottalized onsets in word-initial position might perceptually suffer if not preceded by a vowel.

However, investigation of other languages shows that these patterns do not always hold. In Lai, there is substantial variation in the location of glottalization, which can only occur in coda position, but it tends to be preglottalized (Plauché et al., 1998). Likewise, glottalized nasals in Deg Xinag codas are also preglottalized (Hargus, 2016), as are

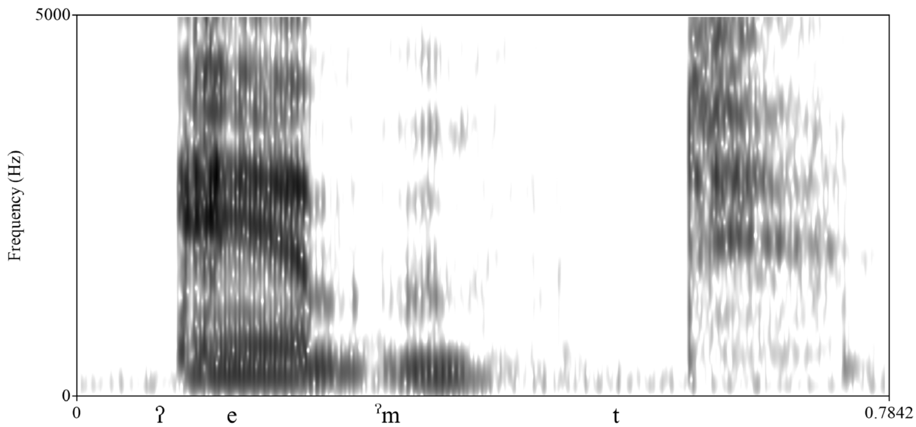

FIGURE 5 Example of glottalized nasal ([ˀm]) in Montana Salish ([ʔeˀmt], "feed")

glottalized sonorants in Yurok (which are devoiced if they occur word finally) (Blevins, 2003). In Hupa, there is an unusual phonemic contrast between root-final preglottalized and postglottalized nasals, which arose because the preglottalized nasals used to be in prevocalic position, but these words underwent an apocape process that eliminated the final short vowel (Gordon, 1996; Gordon & Ladefoged, 2001). Another consideration is the interaction between glottalization and stress; for example, Bird (2011) shows that in St'át'imcets, sonorants are more likely to be realized with glottalization in poststress position as compared when they are the onset of a stressed syllable. She speculates that the acoustic properties of glottalization may obscure the cues to stress, leading to prioritization of the stress cues. Taken together, the studies on glottalized sonorants reflect a debate on whether the timing of creaky phonation is best characterized as phonetic optimization of where the creak is realized, or rather a more abstract phonological element that is controlled various potential factors, including syllable position, word stress, and even grammatical category and morphological concatenation. Pending more phonetic detail, since some of these analyses rely on more cursory or impressionistic descriptions, it seems plausible that the timing of creaky phonation in consonants, even more than in vowels, is influenced both by phonetic recoverability and by phonological patterns that result from sounds coming into contact under various morphological conditions.

This section reviews examples of creaky phonation as a segmental or suprasegmental element that occurs over a relatively short duration and mainly exists for the sake of creating segmental contrast. The timing of creaky phonation in these segments is controlled language-specifically, but notably, there are few cases where the entire vowel or consonant is produced with non-modal phonation, suggesting that listeners need at least some modal phonation to reliably perceive vowel quality and tone. However, there is no physiological limitation requiring creaky phonation to be confined to the duration of a segment, and indeed, it is also found as a prosodic voice quality in a number of languages to indicate functions such as phrasal endings and a signal of turn-taking. This is reviewed in the next section.

4 | CREAKY PHONATION AS A PROSODIC ELEMENT

Creaky voice has been recognized as a prosodic element that speakers implement as an end-of-sentence marker in languages like English, Mandarin, and Finnish (Belotel-Grenie & Grenie, 2004; Callier, 2013; Epstein, 2002; Garellek & Seyfarth, 2016; Henton & Bladon, 1988; Kreiman, 1982; Ogden, 2001; Redi & Shattuck-Hufnagel, 2001; Slifka, 2006; Surana & Slifka, 2006; Wells, 1982). Phrase-final creak refers to creaky phonation that often extends beyond just the last syllable of the phrase (as illustrated in Figure 2), though there are not good estimates for many languages on how far back creaky phonation typically spreads. For British English, Henton and Bladon (1988) is an early experimental investigation of what conditions creaky phonation as an end-of-utterance phenomenon, with male and female Received Pronunciation and Modified Northern participants reading sentences. They quantify the proportion of final syllables and (immediately) non-final syllables that have creaky phonation, reporting that rates of final creaky syllables range from 27 to 80% depending on the speakers' sex and accent, and from 19 to 75% when both non-final and final syllables are considered together. Though there is variability, Henton and Bladon conclude that creaky phonation was a marker of utterance-finality for at least some combinations of dialect and sex in their participants.

Similar experimental findings are reported for American English. Following observations in Lehiste and Wang (1977), Kreiman (1982) demonstrates that creaky phonation is one cue that occurs to signal the end of read sentences, along with other cues such as length of pause, rising or falling intonation, and pre-boundary lengthening. Abdelli-Beruh et al. (2016), who have American English speaking college students read the Grandfather Passage, find that the last word in an utterance has an up to 90% likelihood of being produced with creaky phonation (see also Abdelli-Beruh, Wolk, & Slavin, 2014; Wolk, Abdelli-Beruh, & Slavin, 2012). Slifka (2006) uses measures of airflow and air pressure to investigate the patterns of vocal fold vibration at the ends of sentences, finding a type of unconstricted creaky voice that is produced with vocal fold abduction, while still being accompanied by irregular pitch periods. Since Slifka only reports on four speakers, it is unclear how widespread this type of unconstricted creaky phonation is at the ends of utterances compared to the other the other creak types in Keating et al. (2015) or Drugman et al. (2014).

Researchers have also found similar patterns beyond English. Ogden (2001) reports that in Finnish, creaky phonation at the end of an utterance has a turn-yielding function, whereas a glottal stop at the end of an utterance seems to signify turn-holding in cases such as word-search, self-repair, and when a speaker deems their turn to be incomplete. Jurgec (2007) also reports that creaky phonation in Slovene is found in the final word of an utterance. In Estonian, creaky phonation is more likely not only at the ends of intonational phrases, but also when there is phrase-medial lengthening (Aare, Lippus, & Šimko, 2017). In Mandarin, phrase-final creaky phonation can occur on both the final syllable and the penultimate syllable in the utterance (Belotel-Grenie & Grenie, 2004; Kuang, 2018). These authors also confirm that creaky phonation is additionally found on phrase-medial syllables containing tone 3, as noted in the previous section. Thus, in Mandarin, creaky phonation is used both as an acoustic enhancement of a low-pitched target for a tone contrast, as well as prosodically.

Beyond prosodic uses marking the ends of utterances and turns, it is also claimed that creaky phonation is used to indicate pragmatic information, as well as "prosodic registers" (not to be confused with register in Southeast Asian languages), which Sicoli (2015) introduces to mean the use of voice quality to convey meanings in social interactions. For example, Lee (2015) claims that American English speakers increase their use of creaky phonation when producing phrases that are parentheticals within a sentence. Nguyen, Michaud, Tran, and Mac (2013) find that speaker attitude changes the timing and degree of creaky phonation in Hanoi Vietnamese on sentence-final particles. When speakers are conveying irritation, the particle is produced with creak that starts earlier and lasts for a longer portion of the syllable. Sicoli (2010) observes that creaky phonation indicates that a speaker is seeking commiseration in Lachixío Zapotec and Tzeltal Maya. In Hungarian, speakers seem to produce creaky voice when they are producing more informal or relaxed speech (Kane, Pápay, Hunyadi, & Gobl, 2011).

5 | SOCIAL USES AND PERCEPTUAL EVALUATION OF CREAKY PHONATION

A final way in which speakers implement creaky phonation is as a sociolinguistic element. This ranges from the often-heard claim that American English-speaking women use creaky phonation more than men, to its deployment by speakers as an indicator of alignment with a particular social group. The literature examining both the use of creaky phonation as a sociolinguistic element, as well as its evaluation by listeners is addressed in this section.

In the English-speaking world, the original gender-based finding regarding creaky phonation was that it was most likely among upper class men and speakers of Received Pronunciation in Great Britain (Catford, 1977; Esling, 1978; Henton & Bladon, 1988; Stuart-Smith, 1999; Wells, 1982). In the 2000s, however, a raft of articles in the (mostly) American popular press began to attribute creaky phonation to young women alone. In many pieces, women are explicitly counseled to eliminate "vocal fry" (the term for creaky phonation that caught on in the press) if they hope to succeed in the workplace (Hageman, 2013; Khazan, 2014; Palermo, 2013; Wolf, 2015). Wolf (2015), referring to vocal fry in *The Guardian*, writes "Many devoted professors, employers who wish to move young women up the ranks and business owners who just want to evaluate personnel on merit flinch over the speech patterns of today's young women." Chappelow (2012) provides an anecdote in *Fast Company* about a well-qualified candidate for a job that he did not hire because "of how she talked on the phone. Every sentence ended in a gravelly low vibrato. It was a grating, kazoo-like effect that made the candidate sound immature, unconfident, and, frankly, annoying." In another example, a speech pathologist remarks that vocal fry "has been tied to women being perceived as uncertain and lacking in confidence when they interview" (Mo, 2016).

Despite such comments, a review of research on the distribution of creaky phonation in the speech of male and female American speakers does not find good evidence of an overwhelming prevalence of creaky phonation among (young) female speakers. Some studies suggest that overall women produce more syllables in read sentences or passages with creak than men do (Abdelli-Beruh et al., 2014; Wolk et al., 2012; Yuasa, 2010) (though these studies mainly use a perceptual rather than acoustic criteria to identify creak), while others demonstrate that differences between men and women are either small or absent altogether (Abdelli-Beruh et al., 2016; Irons & Alexander, 2016; Melvin & Clopper, 2015; Pratt, 2018). In fact, the Southern United States male speakers in Irons and Alexander (2016) actually produced proportionally more syllables with creaky phonation (26%) than the female speakers did (8%). As for spontaneous speech, a study using sociolinguistic interviews found greater proportions of creaky phonation for female (27%) than male (8%) American speakers, regardless of whether they were White or Black Washington, D.C. speakers (Podesva, 2013). Another study on spontaneous speech that included only female speakers found that the rates of creaky phonation among younger and middle-aged women did not differ (Oliveira, Davidson, Holczer, Kaplan, & Paretzky, 2016).

Whether or not female speakers do actually produce utterances with a greater proportion of creaky phonation, some research in communication sciences and psychology suggests that there may be negative consequences for women—but not as much for men—who use creaky phonation. Anderson, Klofstad, Mayew, and Venkatachalam (2014) tested whether creaky voice had a measurably negative effect on how listeners rated personality characteristics of speakers using vocal fry in a workplace-like setting. The stimuli consisted of modal and creaky versions of the phrase "Thank you for considering me for this opportunity" produced by both men and women speakers. The listeners were 800 people from around the United States, both men and women. Results show that the creaky tokens are given fewer positive ratings than the modal tokens in general, but listeners judge female speakers more harshly than male speakers on the stimuli containing creaky voice for the qualities of trustworthiness, competence, education, and willingness to hire. On the basis of these results, the authors conclude that "young American women should avoid vocal fry in order to maximize labor market perceptions."[1]

In another study using speech communication disorders students as raters, Ligon, Rountrey, Rank, Hull, and Khidr (2019) concur that negative adjectives can be applied to the voice quality of vocal fry, such as "vain," "apathetic/disinterested," "sleepy," and "bored/unengaged," but they found that some of their participants also used adjectives like "relaxed/chill," "sophisticated," "sexy," and "cool" to describe creaky voice in female speakers.[2] They speculate that women may use creaky phonation in some social situations "to avoid being called lively and aggressive, too feminine and sweet, or worse yet, insecure/hesitant (p. 14)." This "low activation" connotation of creaky phonation is also seen in Gobl and Ni Chasaide (2003), though in their case the low-energy words applied to creaky phonation (and other non-modal phonation like breathy) had both positive and negative valence (e.g., "relaxed," "intimate," and "bored"). Greer and Winters (2015) find that the presence of creaky phonation increases ratings of authoritativeness for female speakers, while creaky phonation for male speakers increases ratings not just of authoritativeness, but also of coolness and attractiveness. Parker and Borrie (2018) show that speech rate and the speaker's pitch in modal speech also affected how listeners judged female speakers' likeability and intelligence. In particular, at lower pitch and faster speech rates, creaky phonation lowered ratings of likeability and intelligence, but faster speech at higher speech rates led to higher scores on likeability when creak was present.

Despite some indications of negative reaction to creaky phonation, and despite the mixed evidence regarding a greater incidence of creaky voice in female speech than in male speech, some researchers speculate that speakers might use creaky phonation nevertheless because it has the effect of lowering a speaker's F0 (Anderson et al., 2014; Yuasa, 2010; Zimman, 2018). Zimman (2018) observes that transgender men may implement creaky phonation in order to access a lower pitch range if they are dissatisfied with the pitch of their voices. It is plausible to surmise that lowering one's habitual pitch could potentially be advantageous in the workplace because studies have shown that both women and men are judged to be more dominant if they have lower pitch (Borkowska & Pawlowski, 2011; Feinberg, DeBruine, Jones, & Perrett, 2008; Fraccaro et al., 2013; Puts, Hodges, Cárdenas, & Gaulin, 2007). If workplace dynamics interact with the use of creaky voice as a proxy for lower pitch, it would be consistent with Yuasa's (2010) claim that creaky voice occurs in female speakers who are "educated" and "upwardly mobile." Davidson (2020) investigates whether listeners do in fact hear utterances that begin as modal and end as creaky as being holistically lower in pitch than fully modal utterances, finding that this is the case for female speakers with a higher modal pitch (~200 Hz) but not for those with a lower modal pitch (~150 Hz).

If female speakers do not reliably produce more creaky phonation than male speakers, but it is nevertheless more associated with them, then it is reasonable to ask whether listeners perceive it more in the speech of female speakers for physical reasons, or whether listeners can hear it equally in male and female speakers but only negatively evaluate it for female ones. That is, perhaps creaky phonation is more salient when compared with a speaker's modal voice that is higher in pitch, as it often is for female speakers, as opposed to speakers with lower F0. Davidson (2019a) presented listeners with fully modal, fully creaky, and partially creaky utterances (which started as modal and ended as creaky), and found that listeners were nearly equally likely to identify creak in the fully and partially creaky utterances regardless of whether the speakers were male or female, or what their average modal F0 was. This suggests that listeners can identify creaky phonation in both men and women, so stronger negative evaluations of women are not because creak is less discernible in men.

Beyond associations with the gender of the speaker, sociolinguistic studies have reported that speakers use creaky phonation to index other aspects of identity. For example, Mendoza-Denton (2011) discusses the case of a Chicano English-speaking girl who uses creaky phonation to signal her hardcore Chicano gangster persona. Szakay (2012) provides evidence that the speech of Māori English speakers in New Zealand is creakier than those of Pakeha English speakers (those of European descent), as measured by H1 − H2 in vowels. Levon (2015) presents a case study of a gay Orthodox Jewish man in Israel to argue that he uses creaky phonation as a way of signaling that both his homosexuality and Orthodox Jewishness are critical if conflicting aspects of his identity. Harkening back to the affect-related perception of creaky phonation, Pratt (2018) argues that creaky phonation is used more by California high schoolers who consider themselves to be more "chill," as compared to their louder peers. She demonstrates that the use of creak is accompanied by bodily gestures that also convey low energy, such as wide legs and a reclined posture.

The studies summarized in this section demonstrate that creaky phonation can be used by a variety of groups for social purposes, but that the interpretation of that use seems to be constrained by who the user is. For some speakers, it may be deployed to convey a "low energy" affect. For speakers who wish to modulate a higher F0, creaky phonation might be a mechanism to achieve a lower pitch. Other speakers may employ it for individual stylistic purposes. Over time, the evaluations that listeners have of creaky phonation may change as different speakers use it for a variety of purposes.

6 | CONCLUSION

Creaky phonation can be implemented either over short elements such as individual phonemes or longer stretches, as long as there are vowels and sonorants in an utterance. This makes creaky phonation a versatile phonetic property that has taken on many roles. A basic function of creaky phonation is to give rise to segmental contrast, as in languages that have series of modal and creaky vowels, as in Oto-Manguean languages, or modal and glottalized sonorants, as in Athabaskan languages. Because creaky phonation is quite salient, it is helpful for reinforcing contrasts with other primary acoustic cues that might benefit from multiple cues, such as tones 3 and 4 in Cantonese and Mandarin. Creaky phonation also frequently arises as a variant or lenition of glottal stop.

When produced in longer stretches, creaky phonation can be used either for prosodic purposes, or it can be deployed in social contexts surrounding identity or affect. A basic cross-linguistic function of creaky phonation is as a phrase-final marker, and this use seems to transcend gender and age. It can also be used to convey certain meanings in social interactions, such as irritation or commiseration. As a sociolinguistic element, creaky phonation can be used by speakers to distinguish them from other groups, as in the example of Māori versus Pakeha New Zealand English speakers. As with any social use of language, creaky phonation is also a target of subjective evaluation. While historically in the English-speaking world creaky phonation was associated with upper class male Received Pronunciation speakers, currently it is more likely to be pejoratively connected with younger (often white American) women. Despite a few studies of creaky phonation as a prosodic or sociolinguistic element in languages other than English, this remains a relatively understudied area that deserves further cross-linguistic attention.

ACKNOWLEDGMENTS

I would like to thank the members of the NYU Phonetics and Experimental Phonology Lab (PEP Lab) for discussing several of the issues that are raised in this article with me. I also thank two anonymous reviewers for their helpful comments.

CONFLICT OF INTEREST

The author has declared no conflicts of interest for this article.

ORCID

Lisa Davidson https://orcid.org/0000-0001-7798-574X

ENDNOTES

[1] The sound files that Anderson et al. (2014) used are available on the PLOS ONE website, and initial inspection indicates a few potential concerns about the unnaturally produced creaky phonation. In some utterances, talkers also elongated syllables in a way that could compound the negative perception of creaky voice. Moreover, relying on the visual acoustic criteria described in the linguistic literature for identifying creaky voice, many of the supposed modal voice tokens also have at least some phrase-final creaky voice, though the duration of creaky voice is a little longer in the "vocal fry" utterances.

[2] A limitation of Ligon et al. (2019) is that the participants were not rating actual speech samples, but rather the concept of the voice quality itself, after participating in a training on voice qualities as part of their graduate study. Though even rating voice samples may come with confounds, the Ligon et al. method may introduce even more bias if the students had been taught that some voice qualities are pathological or dispreferred among voice professionals.

RELATED WIRES ARTICLE

Speech perception and production

REFERENCES

Aare, K., Lippus, P., & Šimko, J. (2017). Creak as a feature of lexical stress in Estonian. *Proceedings of Interspeech*, *2017*, 1029–1033.

Abdelli-Beruh, N., Drugman, T., & Red Owl, R. H. (2016). Occurrence frequencies of acoustic patterns of vocal fry in American English speakers. *Journal of Voice*, *30*(6), 759.e711–759.e720. http://www.sciencedirect.com/science/article/pii/S0892199715002118

Abdelli-Beruh, N., Wolk, L., & Slavin, D. (2014). Prevalence of vocal fry in young adult male American English speakers. *Journal of Voice*, *28*(2), 185–190.

Alber, B. (2001). Regional variation at edges: Glottal stop epenthesis and dissimilation in Standard and Southern varieties of German. *Zeitschrift für Sprachwissenschaft*, *20*, 3–41.

Anderson, R., Klofstad, C., Mayew, W., & Venkatachalam, M. (2014). Vocal fry may undermine the success of young women in the labor market. *PLoS One*, *9*(5), e97506. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0097506

Andruski, J. E., & Ratliff, M. (2000). Phonation types in production of phonological tone: The case of Green Mong. *Journal of the International Phonetic Association*, *30*(1–2), 37–61. https://doi.org/10.1017/S0025100300006654

Avelino, H. (2010). Acoustic and electroglottographic analyses of nonpathological, nonmodal phonation. *Journal of Voice*, *24*, 270–280.

Baird, B. (2011). Phonetic and phonological realizations of 'broken glottal' vowels in K'ichee'. In K. Shklovsky, P. M. Pedro, & J. Coon (Eds.), *Proceedings of formal approaches to Mayan linguistics: MIT working papers in linguistics* (Vol. 63, pp. 39–49). Cambridge: MITWPL.

Batliner, A., Burger, S., Johne, B., & Kiessling, A. (1993). MÜSLI: A classification scheme for laryngealizations. In *Proceedings of the ESCA workshop on prosody* (pp. 176–179).

Belotel-Grenie, A., & Grenie, M. (1997). Types de phonation et tons en chinois standard. *Asie Oriental*, *26*(2), 249–279.

Belotel-Grenie, A., & Grenie, M. (2004). *The creaky voice phonation and the organisation of Chinese discourse*. Paper presented at the Proceedings of the International Symposium on Tonal Aspects of Languages, Beijing, China.

Bennett, R. (2016). Mayan phonology. *Language and Linguistics Compass*, *10*(10), 469–514.

Bird, S. (2011). The nature of laryngealization in St'át'imcets laryngealized resonants. *International Journal of American Linguistics*, *77*(2), 159–184. https://doi.org/10.1086/658893

Blankenship, B. (2002). The timing of nonmodal phonation in vowels. *Journal of Phonetics*, *30*, 163–191.

Blevins, J. (2003). The phonology of Yurok glottalized sonorants: Segmental fission under syllabification. *International Journal of American Linguistics*, *69*, 371–396.

Blomgren, M., Chen, Y., Ng, M., & Gilbert, H. R. (1998). Acoustic, aerodynamic, physiologic, and perceptual properties of modal and vocal fry registers. *Journal of the Acoustical Society of America*, *103*, 2649–2658.

Borkowska, B., & Pawlowski, B. (2011). Female voice frequency in the context of dominance and attractiveness perception. *Animal Behaviour*, *82*(1), 55–59. http://www.sciencedirect.com/science/article/pii/S0003347211001394

Brunelle, M. (2005). *Register in Eastern Cham: Phonological, phonetic and sociolinguistic approaches*. (PhD dissertation). Cornell University, Ithaca.

Brunelle, M., & Finkeldey, J. (2011). *Tone perception in Sgaw Karen*. Paper presented at the Proceedings of the 17th International Congress of Phonetic Sciences, Hong Kong.

Brunelle, M., & Kirby, J. (2016). Tone and phonation in Southeast Asian languages. *Language and Linguistics Compass*, *10*(4), 191–207.

Brunelle, M., Nguyên, D. D., & Nguyên, K. H. (2010). A laryngographic and laryngoscopic study of Northern Vietnamese tones. *Phonetica*, *67*(3), 147–169. https://doi.org/10.1159/000321053

Callier, P. (2013). *Linguistic context and the social meaning of voice quality variation*. (PhD dissertation). Georgetown University, Washington, D.C.

Catford, J. C. (1964). Phonation types: The classification of some laryngeal components of speech production. In D. Abercrombie (Ed.), *English phonetic texts* (pp. 26–37). London, England: Faber.

Catford, J. C. (1977). *Fundamental problems in phonetics*. Bloomington: Indiana University Press.

Chappelow, C. (2012, April). The verbal tic of doom: Why the "vocal fry" is killing your job search. *Fast Company*. Retrieved from https://www.fastcompany.com/1834461/verbal-tic-doom-why-vocal-fry-killing-your-job-search

Childers, D. G., & Lee, C. K. (1991). Vocal quality factors: Analysis, synthesis, and perception. *The Journal of the Acoustical Society of America*, *90*(5), 2394–2410.

Cho, T., & Keating, P. (2001). Articulatory and acoustic studies on domain-initial strengthening in Korean. *Journal of Phonetics*, *29*, 155–190.

Cohen Priva, U., & Gleason, E. (2020). The causal structure of lenition: A case for the causal precedence of durational shortening. *Language*, *92*, 413–448.

Davidson, L. (2019a). The effects of pitch, gender, and prosodic context on the identification of creaky voice. *Phonetica*, *76*, 235–262. https://doi.org/10.1159/000490948

Davidson, L. (2019b). Perceptual coherence of creaky voice qualities. In *Proceedings of the international congress of phonetic sciences 2019* (pp. 1–5). Melbourne, Australia.

Davidson, L. (2020). Contributions of modal and creaky voice to the perception of habitual pitch. *Language*, *96*(1), e22–e37.

Davidson, L., & Erker, D. (2014). Hiatus resolution in American English: The case against glide insertion. *Language*, *90*(2), 482–514.

DiCanio, C. (2009). The phonetics of register in Takhian Thong Chong. *Journal of the International Phonetic Association*, *39*, 162–188.

DiCanio, C. (2012). Coarticulation between tone and glottal consonants in Itunyoso Trique. *Journal of Phonetics*, *40*, 162–176.

Dilley, L., Shattuck-Hufnagel, S., & Ostendorf, M. (1996). Glottalization of word-initial vowels as a function of prosodic structure. *Journal of Phonetics*, *24*, 423–444.

Drugman, T., Kane, J., & Gobl, C. (2014). Data-driven detection and analysis of the patterns of creaky voice. *Computer Speech and Language*, *28*, 1233–1253.

Edmonson, J., & Esling, J. (2006). The valves of the throat and their functioning in tone, vocal register and stress: Laryngoscopic case studies. *Phonology*, *23*, 157–191.

Epstein, M. (2002). *Voice quality and prosody in English*. (PhD dissertation). UCLA, Los Angeles.

Esling, J. (1978). *Voice quality in Edinburgh: A sociolinguistic and phonetic study*. (PhD dissertation). University of Edinburgh.

Esling, J. (1984). Laryngographic study of phonation type and laryngeal configuration. *Journal of the International Phonetic Association*, *14*(2), 56–73. https://doi.org/10.1017/S0025100300002796

Esling, J., Fraser, K., & Harris, J. (2005). Glottal stop, glottalized resonants, and pharyngeals: A reinterpretation with evidence from a laryngoscopic study of Nuuchahnulth (Nootka). *Journal of Phonetics*, *33*, 383–410.

Esling, J., & Harris, J. (2005). States of the glottis: An articulatory phonetic model based on laryngoscopic observations. In W. Hardcastle & J. M. Beck (Eds.), *A figure of speech: A Festschrift for John Laver* (pp. 347–383). Mahwah, NJ: Lawrence Erlbaum.

Esling, J., Moisik, S., Benner, A., & Crevier-Buchman, L. (2019). *Voice quality: The laryngeal articulator model*. Cambridge: Cambridge University Press.

Esposito, C. (2003). *Santa Ana del Valle Zapotec phonation*. (Master's thesis). UCLA.

Feinberg, D., DeBruine, L., Jones, B., & Perrett, D. (2008). The role of femininity and averageness of voice pitch in aesthetic judgments of women's voices. *Perception*, *37*(4), 615–623. http://journals.sagepub.com/doi/abs/10.1068/p5514

Fischer-Jørgensen, E. (1989). Phonetic analysis of the stød in Standard Danish. *Phonetica*, *46*(1–3), 1–59. https://doi.org/10.1159/000261828

Fougeron, C. (2001). Articulatory properties of initial segments in several prosodic constituents in French. *Journal of Phonetics*, *29*(2), 109–135. https://doi.org/10.1006/jpho.2000.0114

Fougeron, C., & Keating, P. (1997). Articulatory strengthening at the edges of prosodic domains. *Journal of the Acoustical Society of America*, *101*, 3728–3740.

Fraccaro, P. J., O'Connor, J. J. M., Re, D. E., Jones, B. C., DeBruine, L. M., & Feinberg, D. R. (2013). Faking it: Deliberately altered voice pitch and vocal attractiveness. *Animal Behaviour*, *85*(1), 127–136. https://doi.org/10.1016/j.anbehav.2012.10.016

Frazier, M. (2013). The phonetics of Yucatec Maya and the typology of laryngeal complexity. *Language Typology and Universals*, *66*, 7–21.

Galea, L. (2016). *Syllable structure and gemination in Maltese*. (PhD dissertation). University of Cologne, Cologne, Germany.

Garellek, M. (2012). The timing and sequencing of coarticulated non-modal phonation in English and White Hmong. *Journal of Phonetics*, *40*, 152–161.

Garellek, M. (2013). *Production and perception of glottal stops*. (PhD dissertation). University of California, Los Angeles.

Garellek, M. (2014). Voice quality strengthening and glottalization. *Journal of Phonetics*, *45*, 106–113.

Garellek, M. (2015). Perception of glottalization and phrase-final creak. *Journal of the Acoustical Society of America*, *137*(2), 822–831.

Garellek, M. (2019). The phonetics of voice. In W. Katz & P. Assmann (Eds.), *Handbook of phonetics*. New York, NY: Routledge.

Garellek, M., & Keating, P. (2011). The acoustic consequences of phonation and tone interactions in Jalapa Mazatec. *Journal of the International Phonetic Association*, *41*(2), 185–205. https://doi.org/10.1017/S0025100311000193

Garellek, M., & Seyfarth, S. (2016). Acoustic differences between English /t/ glottalization and phrasal creak. *Proceedings of Interspeech*, *2016*, 1054–1058.

Gerfen, C., & Baker, K. (2005). The production and perception of laryngealized vowels in Coatzospan Mixtec. *Journal of Phonetics*, *33*(3), 311–334. https://doi.org/10.1016/j.wocn.2004.11.002

Gerratt, B., & Kreiman, J. (2001). Toward a taxonomy of nonmodal phonation. *Journal of Phonetics*, *29*, 365–381.

Gobl, C., & Ni Chasaide, A. (2003). The role of voice quality in communicating emotion, mood and attitude. *Speech Communication*, *40*(1), 189–212. http://www.sciencedirect.com/science/article/pii/S0167639302000821

Gordon, M. (1996). The phonetic structures of Hupa. In I. Maddieson (Ed.), *Fieldwork studies of targeted languages IV (UCLA working papers in phonetics 93)* (pp. 1–24). Los Angeles: UCLA Phonetics Lab.

Gordon, M., & Ladefoged, P. (2001). Phonation types: A cross-linguistic overview. *Journal of Phonetics*, *29*, 383–406.

Greer, S., & Winters, S. (2015). The perception of coolness: Differences in evaluating voice quality in male and female speakers. In T. S. C. f. I. 2015 (Ed.), *Proceedings of the 18th international congress of phonetic sciences*. Glasgow, Scotland.

Grønnum, N., & Basbøll, H. (2007). Danish stød: Phonological and cognitive issues. In M. J. Solé, P. Beddor, & J. Ohala (Eds.), *Experimental approaches to phonology* (pp. 192–206). Oxford: Oxford University Press.

Grønnum, N., Vazquez-Larruscaín, M., & Basbøll, H. (2013). Danish Stød: Laryngealization or Tone. *Phonetica*, *70*(1–2), 66–92. https://doi.org/10.1159/000354640

Gurevich, N. (2011). Lenition. In M. van Oostendorp, C. Ewen, E. Hume, & K. Rice (Eds.), *The Blackwell companion to phonology*. New York: Blackwell Publishing.

Hageman, W. (2013). Stop! You're hurting my ears! *Chicago Tribune*. Retrieved from https://www.chicagotribune.com/lifestyles/sc-fam-0723-voice-control-20130723-story.html

Hargus, S. (2016). Deg Xinag word-final glottalized consonants and voice quality. In H. Avelino, M. Coler, & L. Wetzels (Eds.), *The phonetics and phonology of laryngeal features in native American languages* (pp. 71–128). Leiden, Netherlands: Brill.

Harris, J. (2001). States of the glottis of Thai voiceless stops and affricates. In K. Tingsabadh & A. Abramson (Eds.), *Essays in Tai linguistics* (pp. 3–11). Bangkok: Chulalongkorn University Press.

Henton, C., & Bladon, A. (1988). Creak as a sociophonetic marker. In L. Hyman & C. Li (Eds.), *Language, speech and mind: Studies in honor of Victoria A. Fromkin* (pp. 3–29). London, England: Routledge.

Henton, C., Ladefoged, P., & Maddieson, I. (1992). Stops in the world's languages. *Phonetica*, *49*(2), 65–101. https://doi.org/10.1159/000261905

Hirose, H. (1997). Investigating the physiology of laryngeal structure. In W. Hardcastle & J. Laver (Eds.), *The handbook of phonetic sciences* (pp. 116–136). Oxford: Blackwell.

Hollien, H. (1974). On vocal registers. *Journal of Phonetics*, *1974*(2), 124–144.

Hollien, H., & Michel, J. F. (1968). Vocal fry as a phonational register. *Journal of Speech and Hearing Research*, *11*, 600–604.

Hollien, H., Moore, P., Wendahl, R., & Michel, J. (1966). On the nature of vocal fry. *Journal of Speech, Language and Hearing Research*, *9*, 245–247.

Hollien, H., & Wendahl, R. (1968). Perceptual study of vocal fry. *Journal of the Acoustical Society of America*, *43*, 506–509.

Howe, D., & Pulleyblank, D. (2001). Patterns and timing of glottalisation. *Phonology*, *18*(1), 45–80. https://doi.org/10.1017/S0952675701004018

Irons, S. T., & Alexander, J. E. (2016). Vocal fry in realistic speech: Acoustic characteristics and perceptions of vocal fry in spontaneously produced and read speech. *The Journal of the Acoustical Society of America*, *140*(4), 3397–3397. https://doi.org/10.1121/1.4970891

Ishi, C., Sakakibara, K.-I., Ishiguro, H., & Hagita, N. (2008). A method for automatic detection of vocal fry. *IEEE Transactions on Audio, Speech and Language Processing*, *16*(1), 47–56.

Jurgec, P. (2007). *Creaky voice in Slovene*. Paper presented at the II Congresso Internacional de Fonética Experimental, Santiago de Compostela.

Kane, J., Pápay, K., Hunyadi, L., & Gobl, C. (2011). On the use of creaky in Hungarian spontaneous speech. In *Proceedings of the 17th international congress of phonetic sciences* (pp. 1014–1017).

Katz, J. (2016). Lenition, perception and neutralisation. *Phonology*, *33*(1), 43–85. https://doi.org/10.1017/S0952675716000038

Keating, P., Cho, T., Fougeron, C., & Hsu, C.-S. (2003). Domain-initial strengthening in four languages. In J. Local, R. Ogden, & R. Temple (Eds.), *Phonetic interpretation (papers in laboratory phonology 6)* (pp. 143–161). Cambridge: Cambridge University Press.

Keating, P., Garellek, M., & Kreiman, J. (2015). Acoustic properties of different kinds of creaky voice. In T. S. C. f. I. 2015 (Ed.), *Proceedings of the 18th internatinal congress of phonetic sciences*. Glasgow, Scotland.

Keating, P., & Kuo, G. (2012). Comparison of speaking fundamental frequency in English and Mandarin. *Journal of the Acoustical Society of America*, *132*(2), 1050–1060.

Khazan, O. (2014, May). Vocal fry may hurt women's job prospects. *The Atlantic*. Retrieved from https://www.theatlantic.com/business/archive/2014/05/employers-look-down-on-women-with-vocal-fry/371811/

Kimura, L. L. K. (Producer). (2020). Kani'āina, ulukau.org Digital Repository of Ka Haka 'Ula O Ke'elikōlani College of Hawaiian Language, University of Hawai'i at Hilo, Ka Leo Hawai'i. [September 19, 1972, April 7, 1972, February 20, 1973, 6, 1973, September 30, 1973, September 26, 1972, February 6, 1973. Larry Lindsey Kauanoe Kimura (presenter); Henry Hanalē Machado (guest); Alice Kema (guest); Mālia Craver (guest); Louis Kaulana'ula Grace (guest); Lydia Līlia Wahinemaika'i Hale (guest); Alice Ku'uleialohapoina'ole Nāmakelua (guest); Abraham Pi'ianāi'a (guest). Retrieved from http://ulukau.org/kaniaina

Kingston, J. (2007). Lenition. In L. Colantoni & J. Steele (Eds.), *Selected proceedings of the 3rd conference on laboratory approaches to Spanish Phonology* (pp. 1–31). Somerville, MA: Cascadilla Proceedings Project.

Kirby, J. (2010). Dialect experience in Vietnamese tone perception. *The Journal of the Acoustical Society of America*, *127*, 3749–3757.

Kirchner, R. (2004). Consonant lenition. In B. Hayes, R. Kirchner, & D. Steriade (Eds.), *Phonetically based phonology*. Cambridge: Cambridge University Press.

Kohler, K. J. (1994). Glottal stops and glottalization in German. *Phonetica*, *51*, 38–51.

Kreiman, J. (1982). Perception of sentence and paragraph boundaries in natural conversation. *Journal of Phonetics*, *10*, 163–175.

Kreiman, J., Gerratt, B. R., Garellek, M., Samlan, R., & Zhang, Z. (2014). Toward a unified theory of voice production and perception. *Loquens*, *1*(1) Retrieved from, e009. http://loquens.revistas.csic.es/index.php/loquens/article/view/8/18

Kreiman, J., & Sidtis, D. (2011). *Foundations of voice studies: An interdisciplinary approach to voice production and perception*. Malden, MA: Wiley-Blackwell.

Kuang, J. (2013). The tonal space of contrastive five level tones. *Phonetica*, *70*, 1–23.

Kuang, J. (2017). Covariation between voice quality and pitch: Revisiting the case of Mandarin creaky voice. *The Journal of the Acoustical Society of America*, *142*(3), 1693–1706.

Kuang, J. (2018). The influence of tonal categories and prosodic boundaries on the creakiness in Mandarin. *Journal of the Acoustical Society of America Express Letters*, *143*(6), EL509–EL515.

Kuang, J., & Liberman, M. (2016). The effect of vocal fry on pitch perception. In Z. Ding, W. Zhang, & Z.-Q. Luo (Eds.), *Proceedings of the 41st IEEE international conference on acoustics, speech and signal processing (ICASSP)*. Shanghai: IEEE.

Ladefoged, P., & Johnson, K. (2014). *A course in phonetics* (7th ed.). Stamford, CT: Cengage.

Ladefoged, P., & Maddieson, I. (1996). *The sounds of the world's languages*. Oxford: Blackwell.

Laver, J. (1980). *The phonetic description of voice quality*. Cambridge: Cambridge University Press.

Laver, J. (1994). *The principles of phonetics*. Cambridge: Cambridge University Press.

Lavoie, L. (2001). *Consonant strength: Phonological patterns and phonetic manifestations*. New York: Garland.

Lee, S. (2015). Creaky voice as a phonational device marking parenthetical segments in talk. *Journal of SocioLinguistics*, *19*(3), 275–302.

Lehiste, I., & Wang, W. (1977). Perception of sentence and paragraph boundaries with and without semantic information. In W. Dressler & O. Pfeiffer (Eds.), *Phonologica* (pp. 277–283). Innsbruck, Austria: Institut fur Sprachwissenschaft der Universitat Innsbruck.

Levon, E. (2015). Conflicted selves: Language, religion, and same-sex desire in Israel. In E. Levon & R. Beline Mendes (Eds.), *Language, sexuality, and power: Studies in intersectional sociolinguistics* (pp. 215–239). Oxford: Oxford University Press.

Ligon, C., Rountrey, C., Vaidya Rank, N., Hull, M., & Khidr, A. (2019). Perceived desirability of vocal fry among female speech communication disorders graduate students. *Journal of Voice*. *33*(5), 805.e21–805.e35.

McGlone, R. (1967). Air flow during vocal fry phonation. *Journal of Speech, Language and Hearing Research*, *10*, 299–304.

McGlone, R., & Shipp, T. (1971). Some physiologic correlates of vocal fry phonation. *Journal of Speech, Language and Hearing Research*, *14*, 769–775.

Melvin, S., & Clopper, C. G. (2015). *Gender variation in creaky voice and fundamental frequency*. Paper presented at the Proceedings of the 18th International Congress of Phonetic Sciences, Edinburgh.

Mendoza-Denton, N. (2011). The semiotic hitchhiker's guide to creaky voice: Circulation and gendered hardcore in a Chicana/o gang persona. *Journal of Linguistic Anthropology*, *21*(2), 261–280.

Michaud, A. (2004). Final consonants and glottalization: New perspectives from Hanoi Vietnamese. *Phonetica*, *61*(2–3), 119–146.

Miller, A. L. (2007). Guttural vowels and guttural co-articulation in Ju|'hoansi. *Journal of Phonetics*, *35*(1), 56–84. https://doi.org/10.1016/j.wocn.2005.11.001

Mitterer, H., Kim, S., & Cho, T. (2019). The glottal stop between segmental and suprasegmental processing: The case of Maltese. *Journal of Memory and Language*, *108*, 104034.

Mo, K. (2016, November). Women should avoid using "vocal fry" in the workplace. *The State Press*. Retrieved from http://www.statepress.com/article/2016/10/spopinion-women-should-stop-using-vocal-fry-in-the-workplace

Moisik, S., Esling, J., Crevier-Buchman, L., Amelot, A., & Halimi, P. (2015). *Multimodal imaging of glottal stop and creaky voice: Evaluating the role of epilaryngeal constriction*. Paper presented at the 18th International Congress of Phonetic Sciences, Glasgow, Scotland.

Murry, T. (1971). Subglottal pressure and airflow measures during vocal fry phonation. *Journal of Speech, Language and Hearing Research*, *14*, 544–551.

Murry, T., & Brown, W. S. (1971). Subglottal air pressure during two types of vocal activity: Vocal fry and modal phonation. *Folia Phoniatrica*, *23*, 440–449.

Nguyen, T.-L., Michaud, A., Tran, D.-D., & Mac, D.-K. (2013). *The interplay of intonation and complex lexical tones: How speaker attitudes affect the realization of glottalization on Vietnamese sentence-final particles*. Paper presented at the Proceedings of Interspeech 2013, Lyon, France.

Ni Chasaide, A., & Gobl, C. (1997). Voice source variation. In W. Hardcastle & J. Laver (Eds.), *Handbook of phonetic sciences* (pp. 427–461). Oxford: Blackwell.

Ogden, R. (2001). Turn transition, creak and glottal stop in Finnish talk-in-interaction. *Journal of the International Phonetic Association*, *31*, 139–152.

Oliveira, G., Davidson, A., Holczer, R., Kaplan, S., & Paretzky, A. (2016). A comparison of the use of glottal fry in the spontaneous speech of young and middle-aged American women. *Journal of Voice*, *30*(6), 684–687. https://doi.org/10.1016/j.jvoice.2015.08.015

Palermo, E. (2013, February). Is the way you talk killing your career? *Business News Daily*. Retrieved from https://www.businessnewsdaily.com/4020-vocal-fry-career-damage.html

Parker, M., & Borrie, S. (2018). Judgments of intelligence and likability of young adult female speakers of American English: The influence of vocal fry and the surrounding acoustic-prosodic context. *Journal of Voice*, *32*(5), 538–545.

Pepiot, E. (2014). Male and female speech: A study of mean f0, f0 range, phonation type and speech rate in Parisian French and American English speakers. In N. Campbell, D. Gibbon, & D. Hirst (Eds.), *Proceedings of speech prosody 7*. Dublin, Ireland.

Pierrehumbert, J., & Talkin, D. (1992). Lenition of /h/ and glottal stop. In G. Docherty & D. R. Ladd (Eds.), *Papers in laboratory phonology II: Gesture, segment, prosody* (pp. 90–116). Cambridge: Cambridge University Press.

Plauché, M., Beam de Azcona, R., Roengpitya, R., & Weigel, W. (1998). Glottalized sonorants: A phonetic universal? *Proceedings of the Berkeley Linguistics Society*, *24*, 381–390.

Podesva, R. (2013). Gender and the social meaning of non-modal phonation types. In C. Cathcart, I.-H. Chen, G. Finley, S. Kang, C. Sandy, & E. Stickles (Eds.), *Proceedings of the 37th Annual Meeting of the Berkeley Linguistics Society*. Berkeley, CA: Berkeley Linguistics Society.

Pompino-Marschall, B., & Zygis, M. (2011). Glottal marking of vowel-initial words in German. In *Proceedings of the 17th international congress of phonetic sciences* (pp. 1626–1629).

Pratt, T. (2018). *Affective sociolinguistic style: An ethnography of embodied linguistic variation in an arts high school*. (PhD dissertation). Stanford University, Palo Alto.

Priestly, T. (1976). A note on the glottal stop. *Phonetica*, *33*, 268–274.

Puts, D. A., Hodges, C. R., Cárdenas, R. A., & Gaulin, S. J. C. (2007). Men's voices as dominance signals: Vocal fundamental and formant frequencies influence dominance attributions among men. *Evolution and Human Behavior*, *28*(5), 340–344. https://doi.org/10.1016/j.evolhumbehav.2007.05.002

Quick, P. (2003). *A grammar of the Pendau language*. (PhD dissertation). Australian National University.

Redi, L., & Shattuck-Hufnagel, S. (2001). Variation in the realization of glottalization in normal speakers. *Journal of Phonetics*, *29*(4), 407–429. http://www.sciencedirect.com/science/article/B6WKT-457CJ0P-M/2/88a01c9622ddda96634aeb59930936bd

Sicoli, M. (2010). Shifting voices with participant roles: Voice qualities and speech registers in Mesoamerica. *Language in Society*, *39*(4), 521–553. https://doi.org/10.1017/S0047404510000436

Sicoli, M. (2015). Voice registers. In D. Tannen, H. Hamilton, & D. Schiffrin (Eds.), *Handbook of discourse analysis* (pp. 105–126). Chichester: John Wiley and Sons.

Silverman, D. (1995/1997). *Phasing and recoverability*. New York: Garland Press.

Silverman, D. (1997). Laryngeal complexity in Otomanguean vowels. *Phonology*, *14*, 235–261.

Silverman, D., Blankenship, B., Kirk, P., & Ladefoged, P. (1995). Phonetic structures in Jalapa Mazatec. *Anthropological Linguistics*, *37*(1), 70–88. http://www.jstor.org/stable/30028043

Slifka, J. (2000). *Respiratory constraints on speech production at prosodic boundaries*. (PhD dissertation). MIT, Cambridge, MA.

Slifka, J. (2006). Some physiological correlates to regular and irregular phonation at the end of an utterance. *Journal of Voice*, *20*(2), 171–186.

Stuart-Smith, J. (1999). Glasgow: Accent and voice quality. In P. Foulkes & G. Docherty (Eds.), *Urban voices: Accent studies in the British Isles* (pp. 203–222). London, England: Arnold.

Surana, K., & Slifka, J. (2006). Is irregular phonation a reliable cue towards the segmentation of continuous speech in American English? In *Proceedings of speech prosody 2006, paper 177*.

Szakay, A. (2012). Voice quality as a marker of ethnicity in New Zealand: From acoustics to perception. *Journal of SocioLinguistics*, *16*(3), 382–397.

Umeda, N. (1978). Occurrence of glottal stops in fluent speech. *The Journal of the Acoustical Society of America*, *64*, 88–94.

Wells, J. (1982). *Accents of English* (Vol. 1). Cambridge: Cambridge University Press.

Whalen, D. H., DiCanio, C., Geissler, C., & King, H. (2016). Acoustic realization of a distinctive, frequent glottal stop: The Arapaho example. *The Journal of the Acoustical Society of America*, *139*(4), 2212–2213. https://doi.org/10.1121/1.4950615

Wolf, N. (2015, July). Young women, give up the vocal fry and reclaim your strong female voice. *The Guardian*. Retrieved from https://www.theguardian.com/commentisfree/2015/jul/24/vocal-fry-strong-female-voice

Wolk, L., Abdelli-Beruh, N., & Slavin, D. (2012). Habitual use of vocal fry in young adult female speakers. *Journal of Voice*, *26*(3), 111–116.

Yu, K., & Lam, H.-W. (2014). The role of creaky voice in Cantonese tonal perception. *Journal of the Acoustical Society of America*, *136*(3), 1320–1333.

Yuasa, I. P. (2010). Creaky voice: A new feminine voice quality for young urban-oriented upwardly mobile American women? *American Speech*, *85*(3), 315–337.

Zimman, L. (2018). Transgender voices: Insights on identity, embodiment, and the gender of the voice. *Language and Linguistics Compass*, *12*(8), e12284. https://doi.org/10.1111/lnc3.12284

How to cite this article: Davidson L. The versatility of creaky phonation: Segmental, prosodic, and sociolinguistic uses in the world's languages. *WIREs Cogn Sci*. 2021;12:e1547. https://doi.org/10.1002/wcs.1547