STATES OF THE LARYNX IN LAUGHTER

John H. Esling

Department of Linguistics, University of Victoria, Victoria, BC, Canada
esling@uvic.ca

ABSTRACT

Although laughter can occur in various sequential (horizontal) patterns that have been well described, the voice quality components that can occur in laughter also need to be described in order to constitute a vertical array of possible phonetic contrasts. These components have been referred to as 'states of the larynx' and interact with pitch and with the 'segmental' components of laughter in predictable ways. Changes in laryngeal state can influence the phonetic shape of the voiceless/voiced parameter. Alternations between sources of periodic vibration also play a role in the description of laughter, where these laryngeal components might not otherwise play a role in the phonetics of the given language. Canonical profiles of the principal states of the larynx during various episodes of laughter are demonstrated.

Keywords: states, glottis, larynx, phonation, laryngeal constriction.

1. INTRODUCTION

Recent research into 'voice quality settings of the larynx' and new taxonomic frameworks for interpreting the role of the laryngeal articulator in contributing to vocal quality make it imperative that the accurate phonetic description of 'states of the larynx' in laughter not be taken lightly. Traditionally referred to as 'states of the glottis,' the new paradigm outlines 13 cardinal postures that characterize the positioning of the articulatory structures of the glottis and of the supraglottic laryngeal constrictor mechanism [9, 5]. A reliable depiction of both laryngeal levels is essential because of the likelihood of rapid fluctuations in the control of airflow through the larynx during incidents of laughter and because the states that are adopted during laughter may not be the same as postures typical of an individual's normal speech. Laryngoscopic video movies of the appearance of each canonical state of the larynx during different types of production of laughter are investigated and presented in the form of video files. It is proposed that modifications and combinations of these basic states, along with respiratory airflow control and timing, are key parameters which together may be used to categorize different types of laughter. The basic list of 10 states of the larynx (excluding for the moment as phonatory targets the static, non-continuous states of prephonation, glottal stop, and epiglottal stop) adapted from Esling (2006a) [5] is:

- breath (abduction)
- modal voice (adduction/phonation)
- falsetto (adduction/phonation plus longitudinal stretching – high pitch)
- breathy voice (abduction plus adduction)
- whisper (abduction plus laryngeal constriction)
- whispery voice (abduction plus adduction plus laryngeal constriction)
- creaky voice (adduction/phonation plus laryngeal constriction – low pitch)
- harsh voice – low pitch (adduction/phonation plus laryngeal constriction plus aryepiglottic trilling – low pitch)
- harsh voice – mid pitch (adduction/phonation plus laryngeal constriction – mid pitch)
- harsh voice – high pitch (adduction/phonation plus laryngeal constriction plus longitudinal stretching – high pitch)

2. TAXONOMY AND METHOD

Rather than take a full set of possible voice quality types as the basis for laryngeal activity during laughter, it is more economical to consider the states of the larynx as the basic postures, since each one isolates glottal components (as glottal shapes) from the effects of the laryngeal constrictor (as supraglottic shapes) [7, 4, 3]. Another essential distinction is the product of integrating the supraglottic category and the specification of larynx height. The non-constricted postures are: Lowered larynx voice (low pitch) and Faucalized voice (Lowered larynx, high pitch). The constricted postures are: Pharyngealized voice (raised larynx, low pitch) and Raised larynx voice (high pitch). The tabular relationships presented above are based largely on part (c) of the table of voice quality settings taken from [6] and reproduced in Table 1.

2.1. Voice quality parameters

Table 1: The laryngeal portion of the Table of Voice Quality Settings from Esling (2006b) [6].

Descriptive phonetic labels for voice quality settings

a) Oral vocal tract settings (not included here for the purposes of laughter description)

b) Laryngeal constrictor settings plus larynx height

LARYNGEAL CONSTRICTOR:	***Constricted:***	***Non-constricted:***
	Pharyngealized voice (raised larynx, low pitch)	Lowered larynx voice (low pitch)
	Raised larynx voice (high pitch)	Faucalized voice (Lowered larynx, high pitch)

c) Phonation types (glottal settings plus laryngeal constrictor)

Non-constricted:	***Constricted:***		
	Whisperiness:	*Creakiness:*	*Harshness:*
Breath	Whisper	Creak	
	Whispery creak	Harsh creak	
Breathy voice			
	Whispery voice	Creaky voice	Harsh voice, low pitch
Modal Voice	Whispery creaky voice	Harsh creaky voice	
	Harsh whispery voice	Harsh whispery creaky voice	Harsh voice, mid pitch
	Whispery falsetto	Creaky falsetto	
Falsetto	Whispery creaky falsetto	Harsh creaky falsetto	Harsh falsetto
	Harsh whispery falsetto	Harsh whispery creaky falsetto	
			Harsh voice, high pitch (force increased)

2.2. Method of exploration

In each case, the posture during the production of laughter is explored directly from above by means of a rigid orally-inserted laryngoscope and also by means of a flexible nasally-inserted fibreoptic laryngoscope. The subject in the case of initial exploratory observations with the rigid oral scoping technique was the author. The oral posture adopted during testing of laryngeal parameters was a close variety of schwa [ə] during transoral observation (while the close front vowel [i] is normally used during transnasal observation, designed to advance the tongue and to clear the view over the tongue into the pharynx). The basic laughter sequence adopted for the purposes of exploratory observations (in order to test the relationships between the laryngeal production of a laugh and the range of states outlined in sections 1 and 2.1) was an ‘imitated-laughter’ sequence with a canonical voiceless/voiced alternation, which in its unmarked form would consist of a breath+voice pattern with the voiceless glottal fricative being followed by the target vowel, i.e. [həhəhəhəhə] or [hihihihihi]. Pitch declined over the performance of the syllable string, so that the principal variable would remain the alteration of the laryngeal state itself. That is, pitch was intended to be modified only as a result of the varying states of the larynx. An example of this sequence – a laugh in falsetto mode (stretched vocal folds) – is shown in video 1. The methodology follows previous experimental procedures with languages in which either phonatory register or pharyngeal setting interact with pitch phonemically [4]. The parallel to laughter is one of scale and expectation. Not every language makes extensive use of the laryngeal articulator in its phonology, as a register feature, or for secondary articulations. Those that do have had to be defined in relation to the model in section 2.1. In order for us to be clear about whether laughter varies across this same range of vocal parameters, and whether speech and laughter in a given language use these parameters in the same or different ways, we must apply the full set of auditorily specified (and articulatorily documented) reference parameters, whether or not the given language possesses such features in its speech. The intent of this approach is to elaborate the set of tools available for laughter research, allowing new questions to be asked, such as whether languages that 'speak' in a particular way also 'laugh' in a particular way.

Cases of authentic laughter were drawn from videos produced nasendoscopically that were available in the large set of recordings in the University of Victoria Larynx Research Project. Occasionally during the course of the filming procedure, a subject will laugh during conversation with the researcher or the physician who are carrying out the experiment. Videos were scanned for such haecceitous instances of laughter, which are just as unreflectingly spontaneous as any other unscripted parts of the event. Although the laughter itself is authentically spontaneous, using this adventitious methodology of data collection has the drawback of being sociolinguistically random. The subjects in the data pool represent different ethnic and language backgrounds, and no attempt has been made to determine the reasons why they might laugh the way they do. It may very well be that certain aspects of laughter are generically fixed, while others are individually variable, but without a dedicated methodology to dissect such fine distinctions, the current methodology will be restricted to speculations on what are assumed to be generalized aspects of laughter.

2.3. Consequences

Trying to superimpose a segmental sequence on an underlying long-term posture of the vocal apparatus invokes the voice quality paradox [1, 10]; even a long-term, ostensibly permanent posture can only be quasi-permanent and has intermittent components, some of which are phonetically more indicative of the underlying posture than others. So, maintaining a given laryngeal state over a recurrent voiceless/voiced segmental sequence will sometimes invoke one salient state of the larynx and sometimes another. For instance, maintaining a state of breath throughout the sequence would be unmarked in the case of [h] but would necessitate a consequent change in the value of the vowel to voiceless, [hə̥hə̥hə̥hə̥hə̥]. On the other hand, a breathy-voiced background setting, would induce the consonants of the sequence to become voiced and the otherwise modal vowels to acquire a breathy component, [ɦə̤ɦə̤ɦə̤ɦə̤ɦə̤] (shown in video 2). The same relationship applies to the vowels of whisper, which become voiceless but with whisper stricture [13]; whereas whispery voice affects the quality of the consonants so that they become a whispery-voiced variant of [ḥ], and the vowels are also whispery voiced. A harsh-voice posture at low pitch, where aryepiglottic trilling is present (video 3) may preserve the voiceless/voiced distinction by reshaping the sequence into what is in effect a voiceless/voiced trill sequence [ʜʢ] – or [ʜʢ͜ə] or [ʜʢ͡ə̰] to show that the voiced trilling component co-occurs with the vowel (or [ʜʢ͜i] or [ʜʢ͡ḭ] when the voiced component shares the lingual and labial components of [i]). Although the voiceless/voiced alternation appears to be generically inherent to the nature of laughter [11, 12], the consonant may not always have to be a fricative or trill. Certain states of the larynx may override the breath component and replace it with glottal stop or with a stronger stop closure. Extreme laryngeal constriction in the case of harsh voice at high pitch (shown with the unmarked voiceless onset in video 4) is an example of this – a potential case where the voiceless stricture (consonantal) component of a given individual's style of laughter might become a stop rather than a fricative.

3. RESULTS AND DISCUSSION

3.1. The larynx modelled canonically

Here is a possible remapping of the segmental sequence under the influence of the canonically prescribed laryngeal settings. Despite the long-term overlay, the basic voiceless/voiced opposition is preserved. It is assumed, crucially in voice quality theory, that whispered contexts, as opposed to breath, will evoke the constricted laryngeal setting [cf. 13]; hence the contrast between [h] for breath (unconstricted) and [ḥ] for whisper (constricted) in their respective sequences. The only phonetic factor distinguishing mid-pitch harsh voice from high-pitch harsh voice is pitch (antero-posterior stretching of the glottal vibratory mechanism); but this added component of tension may be enough in some cases to alter the onset consonant in a laughter sequence from a continuant to a plosive. This effect has yet to be tested.

A word about the development of this taxonomy may be useful. 'Breath' and 'voice' (as in 'modal voice') are ancient terms in phonetics that distinguish whether voicing is not present or present during a given sequence. The laugh in falsetto mode (video 1) is equivalent to modal voice in that [h] is voiceless and the vowel adducted for voicing, except that falsetto entails longitudinally stretched vocal folds. If a laugh begins with high pitch and finishes with low pitch, then the first part of the laugh would be more similar to falsetto and the latter part of the laugh would be more similar to modal voice or even to creaky voice. These presumptions depend quite a bit on the language spoken and its sociolinguistic preferences for how laughing should be done. In any culture, however, there is likely to be a range of variety in styles of laughter that indicate different paralinguistic meanings. The 'states of the larynx' approach is designed to account for the changes in laryngeal posture that this range of styles might cover.

Breath is canonically distinct from 'whisper' as a phonetic trait. The breathy-voiced glottal fricative is [ɦ], and the usual diacritic for breathiness is two dots beneath the symbol. Whisperiness is marked by one dot beneath the symbol in conventional voice quality notation, e.g [ɦ̣], although this usage is somewhat paradoxical in the case of the vowel symbol since whisper implies greater laryngeal constriction than breath, not less. Creakiness implies greater laryngeal constriction than for modal voice, inducing a lowering of pitch (fundamental frequency) through the shortening of the vocal folds. Both creakiness and harshness employ the laryngeal constrictor mechanism [3] and can be marked by the same diacritic – a subscript tilde to designate 'laryngealization' – though the fine meaning of how that laryngealization is accomplished articulatorily differs in the two cases. Aryepiglottic trilling is designated here with the voiceless and voiced symbols for 'epiglottal' (i.e. pharyngeal) trills [3]. Thus, when [ʜ] becomes voiced it transforms into [ʢ] which is also accompanied by glottal voicing, hence the use of the tie bar over both symbols and the tilde under the vowel, indicating in this case not only laryngealization but also active supplementary vibration of the supraglottic aryepiglottic folds. Harsh voice at mid pitch and harsh voice at high pitch do not differ in transcription (resembling the case of model voice and falsetto) because the principal factor distinguishing them is the addition of longitudinal stretching to create high pitch. The essential difference between model voice/ falsetto and harsh voice mid/high pitch is the engagement of the laryngeal constrictor for the latter pair.

The following list gives the segmental (CVCV) sequence that each state of the larynx implies, transcribed in narrow phonetic detail:

- breath (relative abduction) [hə̥hə̥hə̥hə̥hə̥]
- modal voice (adduction/phonation) [həhəhəhəhə]
- falsetto (adduction/phonation plus longitudinal stretching – high pitch) [həhəhəhəhə]
- breathy voice (abduction plus adduction) [ɦə̤ɦə̤ɦə̤ɦə̤ɦə̤]
- whisper (abduction plus laryngeal constriction) [ḥə̣̊ḥə̣̊ḥə̣̊ḥə̣̊ḥə̣̊]
- whispery voice (abduction plus adduction laryngeal constriction) [ɦ̣ə̣ɦ̣ə̣ɦ̣ə̣ɦ̣ə̣ɦ̣ə̣]
- creaky voice (adduction/phonation plus laryngeal constriction – low pitch) [hə̰hə̰hə̰hə̰hə̰]
- harsh voice (adduction/phonation plus laryngeal constriction plus aryepiglottic trilling – low pitch) [ʜ͡ʢə̰ʜ͡ʢə̰ʜ͡ʢə̰ʜ͡ʢə̰ʜ͡ʢə̰]
- harsh voice (adduction/phonation plus laryngeal constriction – mid pitch) [ḥə̰ḥə̰ḥə̰ḥə̰ḥə̰]
- harsh voice (adduction/phonation plus laryngeal constriction plus longitudinal stretching – high pitch) [ḥə̰ḥə̰ḥə̰ḥə̰ḥə̰] or [ʔə̰ʔə̰ʔə̰ʔə̰ʔə̰]

3.2. The larynx in spontaneous laughter

It is possible to observe spontaneous laughter using laryngoscopic methodology. Laughter can occur during an experimental session, and the laughter is as spontaneous as the speech that occurs under the same conditions. When using a nasally inserted endoscope with proper technique, subjects do not consider that their speech is abnormal, and neither do listeners, although there may eventually be a build-up of mucus which could become equivalent to speaking while having a slight cold, but this is usually not noticeable.

In this very preliminary sampling of laryngeal behaviour during spontaneous laughter and speech-laugh episodes filmed laryngoscopically, only the basic modes of phonation are observed to occur: modal voice, breathy voice, and falsetto. It is estimated that the subjects were not departing widely from their usual speaking voice qualities when breaking into laughter. It is perhaps significant that the filming circumstances (and experimental conditions) were not wildly hilarious to begin with and that the laughter could most probably be classified as nervous and/or polite. It certainly did not cover a range of possible types of laughter that one might expect from a professional actor performing a series of laughs for comedic effect, for example. In order to explain all possible eventualities in the use of the larynx in generating the classic abduction-adduction alternation of a laughter episode, it might be possible to ask an actor, or persons with particularly interesting target laughter, to perform their laughter under laryngoscopic examination. This tactic, however, has not been adopted here and is perhaps not well advised. It is more reliable in phonetic research of this sort to establish cardinal reference points generated under phonetically controlled conditions with clear auditory targets and then to share the auditory targets and their articulatory correlates with other phonetic judges who can listen to laughter data and categorize the various shifts in laryngeal state. This is the approach that has been taken in our parallel research into the earliest speech sound production by infants [8, 2], where laryngoscopic intervention would not be ethical. Similarly, our laryngoscopic work with adults speaking various languages [4] serves as the basis for identifying how the larynx functions; then the knowledge of the auditory/articulatory correlates of possible sound production types is applied to the description of data sets of infant sound production [2]. Our recommendation in the study of laughter repertories is to follow this same practice of phonetically instructed listening.

In our films of spontaneous laughter episodes, six instances have been isolated from three subjects, all female and in their 20s in this case, and examined as an introduction to the laryngeal behaviour of laughs. It is clear that the basic pattern of abduction (breath, in all of the cases observed here) and adduction (glottal voicing) is being respected.

For the first subject, pitch appears to be within the normal range of her speech; and in three cases, her laughter represents her normal speaking voice quality (essentially modal voice). In one case, perhaps due to the context of the task, where high pitch was the experimental target, her laughter was higher-pitched, approaching falsetto as a canonical referent.

The second subject's speech-laugh is breathier than her normal voice. Articulatorily, her glottis is wider open in the abduction phase and for longer periods than in the modal-voice laughs of subject 1. Airflow is also presumably greater, but this has not been measured. The type of laughter in this case could be characterized as breathy-voiced laughter.

The third subject also produces a laugh that is slightly different from her normal voice, perhaps only by its being exaggerated, but this would be a matter for experimentation to resolve. Her laugh appears to have higher-volume air flow than her speech (not measured) with articulatorily wide abduction phases. The context of the experimental task involved the production of a strong glottal stop just before the laugh, although this would also be a case where experimentation is needed to resolve the influence of context on the quality of subsequent laughter. Another possible factor in the analysis of this laugh is the noticeably long voiceless expulsion of breath at the onset of the laugh. This significant initial expending of subglottal air could have an effect on the pressure variables during the voicing components of the laugh. From a pitch perspective, there appears to be a shift upwards from the subject's normal pitch range, at the same time as breath is being forcefully expelled. This creates the conditions for the voicing quality to be both higher-pitched and breathy at the same time, which would not be predicted based on the normal distribution of breathy voice (usually in the lower end of the pitch range) [10, 3].

This final, sixth instance of unscripted spontaneous laughter from our preliminary laryngoscopic observations causes us to consider a number of points. First, it appears to be likely that a person's laughter can be produced in a different mode from their normal speaking voice quality. This is based on woefully limited data, from two subjects out of three. More significantly though, the quality of subject 3's laugh suggests that airflow parameters will be critical in determining the kind of voicing that is produced during the adduction phase. Pitch is also recognized to be a powerful variable in altering the perception of phonetic quality; for example, the two constricted settings in Table 1(b) involve the same articulatory posture with only a difference in pitch level, and the two unconstricted settings in Table 1(b) involve the same articulatory posture with only a difference in pitch level. This last example in our set could not be called whispery, because the voiceless phases are too wide and therefore would have to be labelled breathy; and it is clearly not constricted either. Based on auditory phonetic analysis [10, 6], this laugh can be characterized as an example of faucalized voice (lowered larynx, high pitch), which is the opposite in posture to a constricted state. In faucalized voice, larynx position is low (as for lowered larynx voice) but pitch is high. In the video data, the supraglottic space is open, not constricted, the larynx can be seen to lower, and the antero-posterior distance remains relatively long, confirming (or at least visually illustrating) the auditory analysis.

In conclusion, it is perhaps worth emphasizing that states of the larynx are a critical component of the analysis of laughter since laughter inherently comprises, by definition, a rapid alternation between two distinct states of the larynx/glottis. This means that laughter is a phenomenon that is already identified on the basis of a contrast in laryngeal states. What those states are can also differ in voice quality, just as various speaking styles can differ in voice quality. So two distinct states, such as breath and voice, can also be influenced by an overlay of a supplementary quality that alters one or both of them. A change in the voice quality of laughter has implications for the segmental identity of its composite states, which can be retranscribed following phonetic principles. Another phonetic question to address is whether the aerodynamic components of the contrasting states in laughter are more exaggerated than in speech and therefore require redefinition from the norms identified for speech. Further linguistic questions can be asked once the superordinate voice quality and dependent segmental alternations have been identified, such as how laughter differs from non-laughter modes of an individual's speaking voice, how socially and regionally contrasting groups differ in styles of laughter, and how the acquisition of laughter is related to the acquisition of the speaking modality.

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