Laughing, Breathing, Clicking - The Prosody of Nonverbal Vocalisations

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Abstract

When analysing human spoken communication the focus on the linguistic side lies on speech with its verbal message, whereas the focus on the non-linguistic side usually is on the visually transported information such as gestures and facial expression. However, speech, especially in talk-in-interaction, also features numerous nonverbal vocalisations including various forms of laughter and inhalation noises as their most frequent forms. Although nonverbal vocalisations are usually short in duration they may provide rich information on linguistic, paralinguistic and extralinguistic levels including prosodic phrasing, cognitive load, affective state or speaker identity. The paper provides an overview of the phonetic and prosodic structure and the timing of laughter and audible breathing. Special attention is given on conversational speech, where we can frequently find situations in which interlocutors overlap temporally and on apical click sounds that often occur with inhalation before upcoming articulation but also during word-finding difficulties.

Index Terms: laughing, speech respiration, clicks, paralinguistics, pauses

1. Introduction

Speech communication is concerned with the analysis and processing of *verbal* communication. In contrast*, nonverbal* communication is often associated with *visual* information like gestures from hands, arms, eyes and other parts of the body, particularly the face. However, there is also *vocal* nonverbal communication. Crystal [6] divides the paralinguistic features into *voice qualifiers* (such as whispery, breathy or creaky voice) and *voice qualifications* (like laugh, giggle, sob or cry). The latter group belongs with physiological reflexes (like sneezing, coughing or snoring), to non-word vocalisations that are termed nonverbal vocalisations (NVVs) [47] or non-lexical sounds [51].

Although it is a matter of dispute what counts as verbal and what as nonverbal, for many vocalisations there is no doubt about their non-linguistic status, such as for *vegetative sounds* or physiological reflexes. Snoring, moaning (e.g. in sports), swallowing sounds, chewing noises, hiccup, coughing, sneezing, clearing the throat, yawning or panting (after physical exercise) are not primarily communicative and not all are under voluntary control. Typically, vegetative sounds are not learned. However, there are vegetative sounds that require some level of learning such as lip smacking or blowing one's nose. Some vegetative sounds can be used deliberately like clearing the throat ("ehem") to indicate e.g. "I'm here now". Thus, deliberate vegetative sounds require pragmatic knowledge and the control of the vocal apparatus.

Affect sounds include vocalisations such as laughing, weeping, cheering, crying aloud or screaming and many other types. Conventionalised forms of these affect sounds include the deliberate use of moaning and yawning as well as imitations of coughing and snoring. Often, these vocalisations are called affect bursts, e.g. [35].

Sometimes all sorts of NVVs occur under the umbrella of *interjection*s or *sound objects* [33] as words or utterances with either an emotional and/or an affective connection such as "ouch" or "wow" or as imitative expressions like "miaow" or "knock-knock". There are various grades of lexicalisation among the interjections: "Damned!" or "Shit!" are clearly verbal vocalisations whereas "woosh" or "bing" seem to be less conventionalised. Some interjections are affective words with an ungrammatical phonology such as "pst" or "shh" (no vowels) and "ts-ts-ts-ts" (clicks).

There are further potential candidate utterances for NVVs on the basis of their over-simple or ungrammatical phonotactics. *Hesitation particles*, also known as fillers or filled pauses, such as "uh" or "uhm", can be phonetically regarded as targetless vowels plus a potential neutral nasal consonant. *Feedback utterances* or response tokens include humming signals like "hm" or "yeah" and "uhu" which require hardly any vocal tract control. Usually they are used as backchannel signals but potentially also for asserting and other kinds of attitudinal expression in conversations.

A universal phonetic behaviour is the use of *melodies* with one's own vocal apparatus. Melodies without text can be hummed, sung or whistled but probably not in everyday conversation. In this context the melodies and utterances of babies and toddlers in their pre-linguistic phase should be mentioned where prosody is presumably used without any articulatory targets in the vocal tract.

In conversations, as the most common form of speech communication, NVVs seem to occur more often than in read aloud speech and other forms of controlled speaking situations. An analysis of NVVs in six annotated corpora of conversational speech [47] revealed that breathing noises and laughter were by far the most frequent NVVs in the inspected data. Interestingly, laughs were always present as an annotation category in the different corpora whereas breathing (or similar concepts such as in- or exhalation) was not. Hesitation particles and feedback utterances were usually considered as words and were therefore not counted as NVVs.

In the following sections an overview is given with respect to laughing, breathing and clicking - three phenomena that are linked to the prosodic concept of *pause*. Usually pauses are classified as filled and unfilled pauses [15] whereas the latter are often regarded as silent pauses. Admittedly this 'silence' often contains audible phonetic activity.

2. Laughing

Stereotypically, laughter is associated with a vocal expression of joy that is often spelled "haha". However, investigations of the acoustics of laughter show a huge range of variability for several parameters of "haha"-like laughter. For instance the 'vowel' as the vocal tract reflection in laughing is highly variable between laughs but also in the same laughs [1]. This is also valid for the number of reduplicated laughter 'syllables' and the duration of laughs. In longer laughs, inspiratory breathing can occur at locations of the 'consonant' and there can be an onset and an offset before and after the staccato-like structure of the "haha"-syllables. We note that such a stereotypical laugh shows a great degree of variability and also complexity [42], see Fig. 1[1].

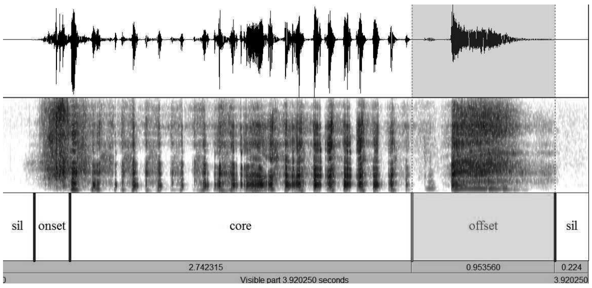

Figure 1: *A complex laugh (as a feedback utterance) with a strong inhalation as an offset (spk R06, duration: 3.9 sec).*

The stereotypical laughs belong to *song-like* laughs [1]. However, not all laughs are alike, as Bachorowksi et al. [1] show in several studies. One important distinction is whether a laugh is voiced or unvoiced [16]. Lab experiments show that females and males use voicing in laughs differently (females prefer voiced laughs) [1, 16]. Unvoiced laughs also have a tendency for conspiracy and less trust [5]. Forms of unvoiced laughter include snort-like and grunt-like variants and sometimes just a short forced exhalation. It becomes clear that laughter is *not only one* form with some variations of this main form but rather *a bundle of forms* with variations for each of these forms.

A special form is the so-called speech-laugh [29, 41] where laughter is produced simultaneously with articulated speech. Note that speech-laughs are different from smiled speech, and that speech can be affected by both, laughing and smiling. In Crystal's terminology [6] speech-laughs and smiled speech belong to voice qualifiers whereas laughs, coughs, sneezes and other NVVs belong to voice qualifications. Speech-laughs can represent a considerable number of all laughs in spontaneous data sets [29, 41, 49] and they are mainly used as self-comments.

Laughter is mainly associated as a signal of emotion displaying happiness, joy, amusement and other forms of well-being. Apart from these positive characteristics there are also negative emotions like maliciousness or simply nervousness. Further important functions of laughter are social bonding or creating affiliation [19]. Presumably, one's decision to join a laughing event, or not to join it, can serve various social functions in addition to transporting affective information.

Investigations of laughs in dialogues reveal that in a considerable number of laughs both speakers overlap with each other (Fig. 2 - as a contrast see a laugh overlapping with speech in Fig. 3). This shared laughter often happens at locations where the speaker with the turn invites the partner to join in the common laugh in order to take the turn [19, 28, 48].

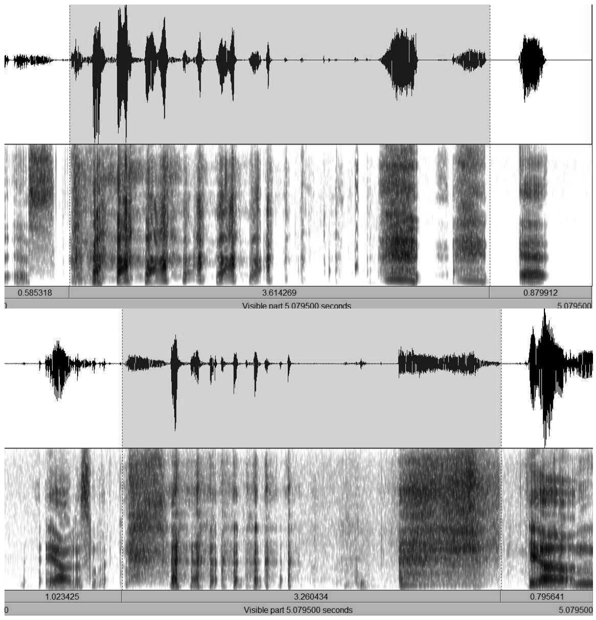

Figure 2: *Overlapping laughter (coloured) with speaker at top (L06) starting to laugh after his speech, speaker at bottom (R06) joining in and taking the turn (duration: 5.0 sec).*

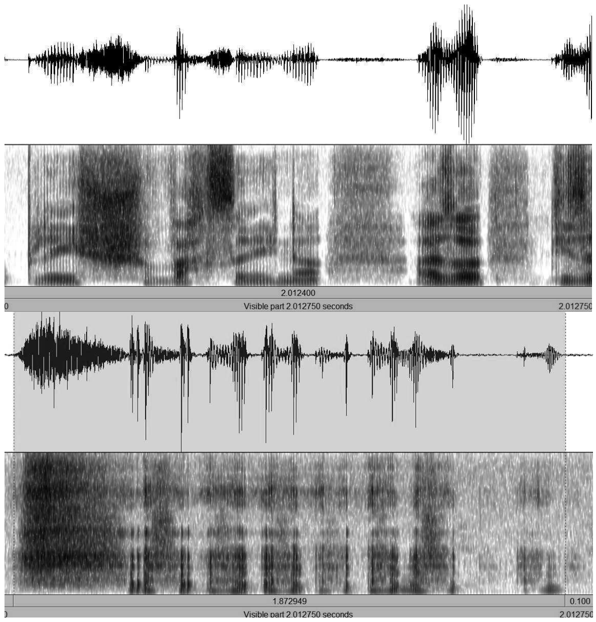

Figure 3: *A laugh at the bottom (R06), starting with an inhalation onset, overlapping with speech of the speaker at the top (L06) (duration: 2.0 sec).*

The prosodic organisation of laughter can be considered at three different levels:

- *The laugh itself.* A voiced laugh follows certain variations of rhythmical, pitch and intensity patterns. Song-

[1] All figures show waveforms and spectrograms (0-8 kHz) of excerpts from the "Lindenstrasse" corpus [18] (six German dialogues, separate channel for each speaker). Acronyms like L06 refer to the left-channel speaker from dialogue 06. L/R02 are female, L/R 06 are male.

like laughter is sometimes characterised as staccato-like. However, a strict application of staccato-like replications of "laugh-syllables" in manipulated laughter leads to the percept of unnaturalness [21].

- *Laugh integrated in the speech*. Laughs are not independent of the preceding articulation phases, e.g. the intensity of a laugh is adapted to the intensity of the preceding speech (cf. [46]). In addition, speech-laughs as vocal productions of speech and laughing by the same speaker at the same time are paralinguistic voice qualifiers and can be seen as tone of voice.
- *Laughing as a construct of interactional behaviour*. A considerable number of laughs in conversations are produced as speaker-overlapping vocalizations. These overlapping laughs (laugh of one speaker overlaps with laugh of the other) show significantly higher values in terms of fundamental frequency, intensity, duration and voicing [48].

3. Breathing

Respiration in speech usually leads to audible noises of breathing which can strongly vary between individuals in terms of duration and intensity of the frication noise [23]. Inhalation noises can be distinguished from exhalation noises and both types can occur as oral or nasal or combined oral-nasal sounds [20].

In read but also in spontaneous speech, audible inhalation noises are usually found in pauses at major prosodic breaks, while pauses that include breathing noises are generally longer than those without breathing [17]. There seems to be a correlation between breath pauses and higher-ranked constituents of the prosodic hierarchy. However, in many prosodic annotation schemes such as ToBI [2], breathing information is not used for determining the boundary strength but should be treated under 'miscellaneous'. Obviously respiration plays a role in controlling and planning linguistic units of various size. The planning of longer phrases is usually indexed by a deeper inhalation with a subsequent, more intensive and/or longer inhalation noise compared to the planning of shorter phrases [11, 34, 53].

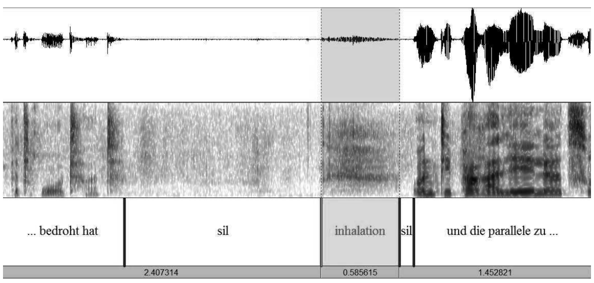

Figure 4: *Audible inhalation at major prosodic break after silence (filled by interlocutor with feedback expression) and before next phrase (speaker R02, duration: 4.5 sec).*

Despite the correlation between inhalation and prosodic planning, the respiratory kinematics of inhalation does not necessarily lead to *audible* breathing noise, as is the case in quiet breathing but also sometimes in speech [45].

Audible breathing can have an impact on how listeners perceive speech tempo. For instance, horse race commentaries are usually described as getting faster the closer the horses are coming to the finish. However, acoustic analyses of those commentaries [43] reveal that the articulation rate remains the same over the race and that the number of pauses increases towards the end instead of decreasing as expected. The main characteristic of these pauses in the final part is that they are shorter and filled with strong inhalation noise - together with an immense increase of the mean pitch.

Paralinguistically, inhalation noises are used for the display of affect such as startle and surprise [35]. Breathing noises are also components of cultural patterns, e.g. as markers of politeness in Korean [54].

Individual patterns of audible breathing and its acoustic correlates are of great interest for forensic research. Duration, intensity and spectral distribution of the frication noise indicate typical differences between individuals [23, 24]. It remains an open question to what extent audible breathing patterns can be reliably associated with the corresponding speaking voice and whether it is possible to impersonators to imitate the breathing of another person.

Attempts to integrate inhalation sounds in speech synthesis are rare. Studies either tested the recall rate and the preference of synthesised sentences with and without preceding breath sounds [52, 44], or inhalation noises were integrated in expressive synthesis as affective sounds [39]. A further example is the modelling of inhalation pauses for speech synthesis beyond single-sentence prosody [3].

As already mentioned in the previous section, audible inhalation can represent a substantial part of laughter, either as an inter-vocalic part dividing two bouts of a voiced song-like laugh or as an offset in a complex laugh (see Fig. 1). Inhalation also plays a role in producing click sounds (in non-click languages) which will be presented in the next section.

4. Clicking

Usually clicks are associated with phonemes occurring in languages in the Southern part of Africa [25, 26]. In contrast to vowels and pulmonic consonants clicks are plosives produced with an ingressive velaric airstream mechanism [22] with two closures, one in the front (i.e. with the lips or the tip of the tongue) and one in the back at the velum, forming a small pocket of air. While both closures are maintained, the tongue moves down. The result is an enlargement of the air pocket and thus a decrease of the pressure of the air therein. Then the front closure is released, followed by the release of the back closure resulting in the click sound.

In 'non-click languages' apical clicks are used as paralinguistic signals, e.g. to express disapproval but also to indicate "yes" or "no" [12]. They can also be used for imitation (e.g. horses) or for addressing animals. Another type are so-called *weak clicks* which are non-intended sounds that come as a coarticulatory by-product [10, 27, 38] when consonants with a closure at the alveolar ridge are followed by a consonant with a velar closing gesture. The release of the alveolar closure followed by the release of the velar closure can lead to a click with a low intensity. Moreover, clicks are used in musical styles with vocal percussion such as beatboxing [32].

In contrast to all the aforementioned uses and types of clicks, recent studies of conversational data in non-click languages such as English and German show that clicks are frequently used for marking new sequences [14, 31, 40, 55, 56], sometimes also to express a stance [31] but also before feedback utterances and when searching for the right words [40], see Figs. 5 and 6.

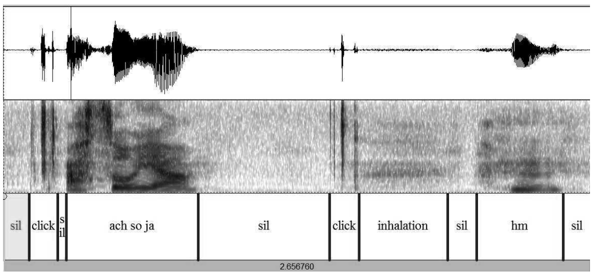

Figure 5: *Two clicks: first click between silence and the feedback utterance "ach so ja" ("I see, yes"), second click between silence and inhalation noise, followed by silence and the feedback token "hm" (speaker R02, duration: 2.6 sec).*

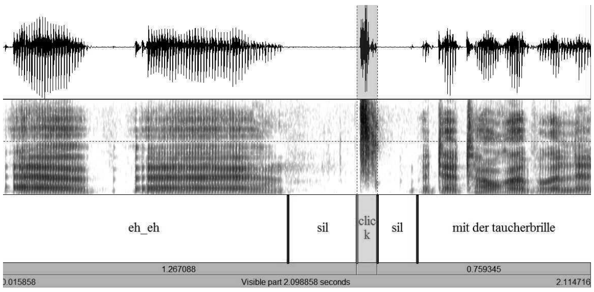

Figure 6: *A click during a word search with two hesitation particles followed by silence, the click, silence and fluent speech (speaker R06, duration: 2.1 sec).*

Interestingly, most speakers of the inspected data sets seem to use clicks, although individual speakers show different frequencies of occurrences. Despite the observed individuality there are limitations of the individual clicking behaviour to be reliably used in forensic phonetics [14].

Producing an apical click is normally unproblematic for a speaker of a "non-click language". The articulation of quasi-lexical items such as "ts-ts" to express disapproval requires a planning of the apical and a tongue body gesture together with inhalation. In contrast to such a conscious choice, the clicks in spontaneous discourse probably occur as by-products of an increased inhalation. Articulatory measurements of speech in preparation show that the tip of the tongue together with the increased inhalation may cause click sounds [37]. Although a velaric airstream cannot be excluded, it is more likely that an inhalation gesture with a sudden and strong vertical downwards movement of the larynx combined with an increased glottal opening provides the necessary negative pressure [9].

It remains an interesting topic for future research whether there is a universal tendency to use clicks as indices for new sequences and other pragmatic functions. The variability of the paralinguistic clicks across languages is still to be explored, particularly their phonetic substances. More knowledge about the phonetics of clicks in languages other than English and German is needed before we can reach a better understanding of what is a vegetative by-product and what is part of a linguistic system.

5. Discussion and conclusion

In vocal communication, particularly in interaction with interlocutors, numerous nonverbal vocalisations can be found. Despite various attempts to describe NVVs [6, 7, 30, 47, 51], a generally accepted framework including a theoretical foundation is missing. For instance, it is a matter of debate whether and which NVVs should be considered as 'conversational grunts' [7, 51].

From the perspective of vocal production, NVVs seem to entail no (or a low) active control of vocal tract configurations. NVVs are mainly characterised by their activities at the subglottal and glottal level and by their temporal control.

Looking at the prosody of NVVs we can see that some NVVs like a voiced laugh (see Fig. 1) show a complex prosodic make-up that can be regarded independently of its neighbouring context. Often NVVs like inhalation noises reveal how they are embedded in their context. Duration and intensity of an inhalation noise provide information on various levels: on the prosodic-syntactic level about the length of the upcoming phrase [11, 53] and the strength of the break [17]; on the prosodic-pragmatic level together with clicks about new sequences [55]; on the paralinguistic level about the degree of arousal [35, 43]; and on the extralinguistic level about patterns typical for certain individuals [13, 23, 24]. In talk-in-interaction, speakers change the prosodic shape of NVVs in accordance with the communication partner as it is the case for speaker-overlapping laughter [48].

Many NVVs occur in speaking situations that are listener-oriented and embedded in a communicative context. They are rarely observed (and not always welcome) in speaker- and text-oriented speech. Speech synthesis, mainly performed as text-to-speech conversion of single utterances, should not ignore NVVs when the aim is to generate more natural and more expressive speech [4]. Synthesis of laughter in isolation [50] is a promising starting point. However, conversational speech synthesis requires a deeper knowledge of the prosody of NVVs. On the recognition side in speech technology, initiatives like the paralinguistic challenges [36] show that NVVs are seen as important social signals.

Most spontaneous discourse (beyond single utterances) contains NVVs. This paper attempted to present the complexity of NVVs by touching upon laughing, breathing and clicking. For a better understanding of the prosody of vocal communication it is time to move the NVVs from the 'miscellaneous' tier to a more systematic description.

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