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Word-initial vowel glottalization in speech of native English non-professionals

Glotalizace iniciálních samohlásek
rodilými neprofesionálními mluvčími angličtiny

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doc. PhDr. Jan Volín, Ph.D.

I would like to thank most sincerely my thesis supervisor doc. Jan Volín for all his helpful comments and insights that he was always ready to provide - and for the love of phonetics that he has inspired in me and, surely, in many others.

I declare that the following BA thesis is my own work for which I used only the sources and literature mentioned, and that this thesis has not been used in the course of other university studies or in order to acquire the same or another type of diploma

Prohlašuji, že jsem bakalářskou práci vypracovala samostatně, že jsem řádně citovala všechny použité prameny a literaturu a že práce nebyla využita v rámci jiného vysokoškolského studia či k získání jiného nebo stejného titulu.

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Abstract

The purpose of this thesis is twofold: i) in the theoretical part to provide a comprehensive overview of the research on glottalization, focusing on representative studies of word-initial glottalization in several languages, and ii) in the research part to bring an analysis of the phenomenon in the read speech of British English native non-professional speakers. The mechanism of distribution and form of word-initial glottalization is not yet fully understood and although its almost unpredictable character has attracted some attention in recent years, descriptions of the phenomenon for the English language are still scarce, if not non-existent in the case of British English. This study aims to serve as a probe in this direction. The material consisted of 1307 word-initial vowels produced by 5 male and 5 female speakers. Based on perceptual and acoustic criteria, three types of glottalization were distinguished: canonical, creaky and breathy. Although the analysis of the corpus showed the expected inter-speaker differences, a clear tendency was discernible for pitch accent to have an effect on glottalization. To a lesser extent, this can be also said about the semantic factor, where content words were glottalized more often. This conclusion, however, was problematised. No clear pattern was distinguished in the distribution of the different kinds of glottalization.

Keywords

word-initial vowel, glottalization, juncture, linking

Abstrakt

Cílem této práce je jednak v teoretické části podat ucelený přehled výzkumu na téma glotalizace, přičemž těžištěm jsou reprezentativní studie zabývající se glotalizací iniciálních samohlásek v několika jazycích. Za druhé práce přináší analýzu tohoto typu glotalizací ve čteném projevu rodilých neprofesionálních mluvčí britské angličtiny. Přesný mechanismus distribuce a realizace zkoumaného jevu zatím není dostatečně popsán. Ačkoliv jistá nevypočitatelnost jevu přispěla v minulých letech ke zvýšenému zájmu o výzkum glotalizací, studie pro angličtinu jsou spíše vzácné a v případě britské variety není žádná studie podobného charakteru k dispozici. Tato práce by měla sloužit jako sonda právě tímto směrem. Analyzovaný material sestával ze 1307 iniciálních samohlásek sesbíraných od pěti mužů a stejného počtu žen. Na základě akustických a percepčních kritérií byly rozlišovány tři typy glotalizací: kanonická, třepená a dyšná. Ačkoliv se v korpusu projevily očekávané rozdíly mezi mluvčími zejména v míře glotalizace, bylo možné odhalit nepopiratelný sklon přízvučných slov ke glotalizaci bez ohledu na mluvčího. Stejná tendence se v menším měřítku projevila i u faktoru sémantického, v jehož případě byla slova plnovýznamová glotalizována častěji. K druhému jmenovanému závěru je nicméně z několika důvodů nutno přistupovat obezřetně. Co se týče typů glotalizace, zdá se, že zkoumané faktory nemají výrazný vliv na jejich distribuci.

Klíčová slova

iniciální samohláska, glotalizace, vázání, předěl

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1. Introduction

Vowel-initial glottalization, the subject of the present study, is a phenomenon belonging in the larger family of glottal gestures that have various forms and functions on different levels of linguistic analysis. Vowel-initial glottalization proves to be especially perplexing because its manifestation, as well as its very presence, is often rather erratic. In many languages, be it those where the older orthoepic descriptions gave straightforward accounts of where glottalization should appear (e.g. German), or those like English, where, partly because of a different approach towards imposing norms on language, this type of glottalization was taken as a free variant, the questions researchers ask are essentially the same: 'What governs the presence or absence of glottalization?' and 'Why are there such marked inter- and intra-speaker differences in the rate and form of glottalization?' Although there are not yet any clear answers, the picture is beginning to gain more definite contours.

The present study brings an analysis of glottalization in British English, based on a sample of read speech produced by ten non-professional speakers. As other studies on the subject, the disparate manifestations of glottalization demanded an attempt at classification. The main criterion adopted here was that of perceptual salience, and consequently, three categories of glottalization were distinguished, namely canonical glottal stop (see 2.1), creaky glottalization (2.2) and breathy glottalization (2.3). In the following chapter, these three categories are described along with a brief overview of the other functions they might attain in English and other languages (see 2.4 and 2.5). Section 2.6 presents a review of vowel-initial glottalization research undertaken in several languages, featuring importantly American English (Dilley, Shattuck-Huffnagel, & Ostendorf, 1996) which naturally serves as a point of comparison in many ways.

The remaining chapters are devoted to the description and analysis of the studied material. Chapter 3 provides a description of the corpus and method. Segmentation is considered in some detail (3.2.1) as well as the difficulties that were encountered (3.3). Chapter 4 brings the results of the analyses. Apart from observing the vowel-initial glottalization behaviour of British non-professional speakers in general (4.1), the study focuses also on the effect of semantic (4.2) and prosodic (4.3) factors which were found to be significant in previous research on the topic. The results and their implications for future research are discussed in Chapter 5.

2. Glottalization in speech

2.1 The canonical glottal stop

Most commonly, the glottal stop in its canonical form is taken to be a voiceless (see page 10 below for discussion) stop consonant with glottal place of articulation. More specifically, it belongs to the class of plosive (also called occlusive) sounds. These are characterised by a complete blockage of the egressive pulmonic airstream at some place in the vocal tract. The production of plosives generally consists of three stages: onset, closure and offset. During the first stage, one articulator approaches another and the ensuing oral closure, which is manifested as a silent interval in the acoustic signal, causes a build-up of air pressure. In natural articulation rate, this may last approximately 40 to 70 milliseconds (Machač & Skarnitzl, 2009, p. 132). With places of articulation other than glottal, there is room for numerous possible glottal variations during the closure: most languages employ voiced and/or voiceless stops (Henton, Ladefoged, & Maddieson, 1992). When the occlusion is released, that is during offset, a short burst of noise follows, as the different levels of air pressure equalise.

Of course, as its name suggests, the place of articulation of the glottal stop is glottal. This means that the closure is achieved by adduction of the arytenoid cartilages and the vocal folds. Moreover, recent research in several languages has suggested that "partial ventricular fold adduction and slight epilaryngeal tube constriction are key components in producing glottal stop" (Esling & Harris, 2003, p. 1049). After the release phase, the vocal folds start to vibrate with an abrupt increase of intensity. The effect may be seen especially on the following vowel, where the time before the vowel reaches its full intensity is significantly shorter compared to vowels not preceded by a glottal stop (Malécot, 1975). The first non-modal periods, i.e. the explosion, tend to be visibly and audibly different from the following segment (Machač & Skarnitzl, 2009, p. 127). See Figure 1 overleaf for an illustration.

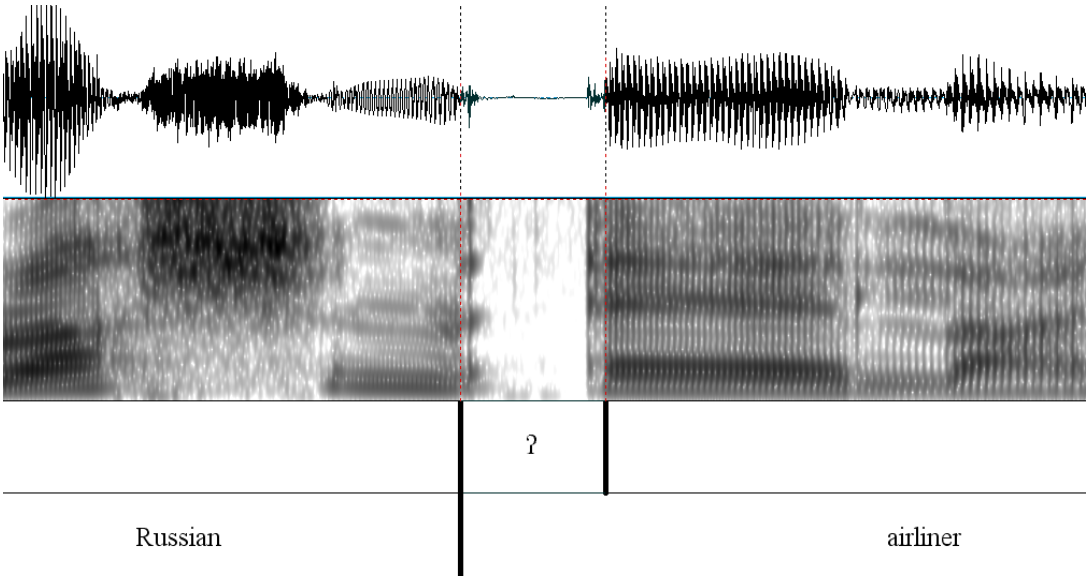

Figure 1. Canonical glottal stop in prevocalic position.

From the articulatory point of view, the three plosive stages can be recognised in a canonical glottal stop, although not all of them may be directly observable in hearing. For utterance-initial glottal stops that precede a vowel, "only the acoustic transient of the release phase is audible" (Pennington, 2005, p. 28). Perceptually, the glottal stop is then characterised as a "sudden cessation of the preceding sound or by the sudden onset (…) of the following [one]" (Cruttenden, 2008, p. 179). Untrained listeners often describe the percept as 'a gap' in the case of intervocalic glottal stops, and as a "sharp edge of the vowel" (Volín, 2003) to speak of the word-initial ones. This sensation is also reflected in the names given to voice onsets, although it must be noted that, especially in English, the terminology is by no means unified. The glottal initiation tends to be connected with hardness or firmness, thus in literature we may encounter *hard attack* (English), *tvrdý hlasový začátek* (Czech) or *fester Einsatz* (German), whereas the gradual onset normally connected with sonorant consonants such as [m] or [w], is dubbed soft (*měkký hlasový začátek* in Czech).

The glottal stop is in many ways dissimilar from the rest of the plosive consonants. A significant difference lies in the fact that the glottal stop has no effect on the formants of surrounding vowels (Kent & Read, 1992, p. 143). In fact, it is these transients that have the most important effect on perception of supralaryngeal oral stops. It can be said that in this way, the glottal stop is perceptually less salient. Another point of difference is governed by articulatory constraints: the variety of phonation types typical for stops of other places of

articulation is not possible for the glottal stop, simply because the glottis is directly employed in the production of this consonant. Lastly, unlike the rest of plosive sounds, the glottal stop lacks a voicing counterpart. It is now usually viewed as voiceless (and is classified as such in the IPA chart) but this is by no means the universally held opinion and occasional evidence has been brought to the contrary. The articulatory perspective allows for two interpretations: the glottal stop is voiceless, because voicing requires vibration of the vocal folds which cannot be tightly adducted and vibrate at the same time. Alternatively, the glottal stop is sometimes taken as voiced (Kent & Read, 1992), or neither voiced, nor voiceless, since voiceless sounds are characterised by open glottis (Cruttenden, 2008, p. 179).

Nevertheless, there are several phonological cues that suggest that the glottal stop behaves rather as a voiceless sound. Mark Pennington (2005) collected evidence of the phonological behaviour of the glottal stop in several languages that shows that voicelessness (breath and whisper) and glottal stricture might belong to the same natural class, dubbed *glottal noise* by Pennington, which is characterised by extreme position of the vocal folds. Furthermore, in some dialects of English, the glottal stop may substitute voiceless plosives, and in the Czech regressive assimilation of voicing it causes the preceding segment to be voiceless. Thus, although the situation is not clear-cut and depends on the particular understanding of voicedness, the glottal stop behaves quite consistently as a voiceless sound in at least some phonological systems.

Naturally, there were some attempts to find a voiced variant of the glottal stop in the world's languages. One of the oft-cited examples was reported by Ladefoged and Maddieson (1996, p. 76). In the Papuan language Gimi, the glottal stop is contrasted with creaky voice. Cognate words in related languages have voiceless sounds where Gimi has a glottal stop and voiced sounds for Gimi creak. As the authors noted, however, this opposition is only phonological and creaky voice in Gimi, strictly speaking, cannot be taken as a 'voiced glottal stop'. It may nevertheless serve as an illustration that the glottal stop and creaky voice, discussed in the next section, are closely related.

2.2 Creaky glottalization

As was suggested above, there exists a certain affinity between the glottal stop and creaky voice. In the case of Gimi, the relation was phonological. Nonetheless, the case is more often phonetic and creaky voice functions as a variant realization of the canonical glottal stop. In

fact, the glottal stop rather tends not to be produced as a full stop. Instead, it is very often manifested as a form of creaky glottalization, i.e. lacking a complete closure (see Figure 2). This happens especially in intervocalic position (Ladefoged & Maddieson, 1996, p. 75; Pierrehumbert & Talkin, 1992, p. 94) and the perceptual effect is the same as for the canonical glottal stop; i.e. creating a 'gap' between the vowels (see p. 9).

Creaky voice (also called creak, glottalization, laryngealization, vocal fry or pulse register phonation; for discussion of terminology see Gerrat & Kreiman, 2001) is a type of non-modal phonation where the open quotient is very low. During this type of phonation, the arytenoid cartilages are drawn together, making the vocal folds thicker and more compact and in extreme case, allowing only the ligamental part to vibrate (Ladefoged, 1971, p. 14). This configuration causes various kinds of irregularities in the signal.

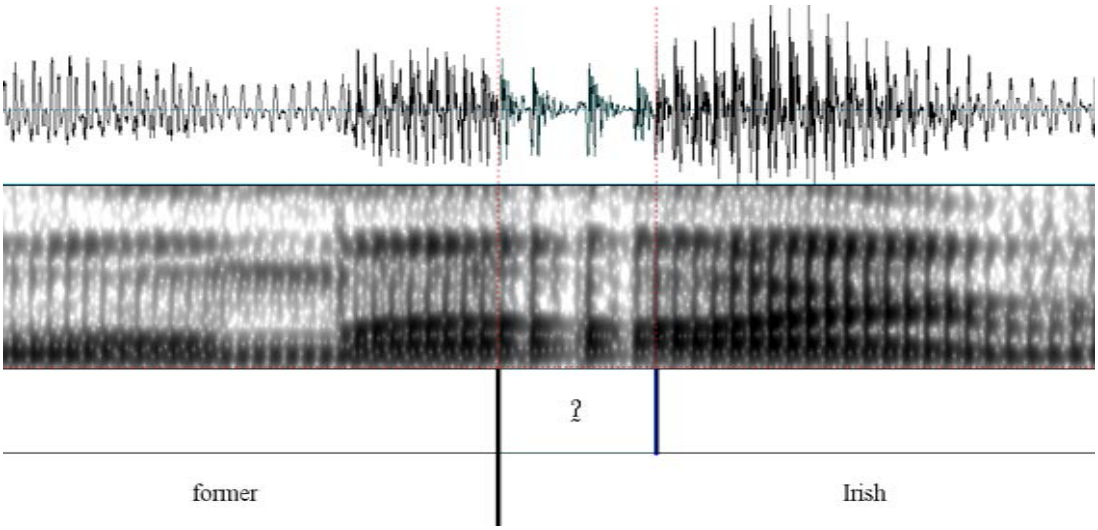

Figure 2. Creaky glottalization.

Generally, creaky voice is characterised by pitch as low as below 60 Hz (Henton & Bladon, 1987, as cited in Klatt & Klatt, 1990). According to Fischer-Jørgensen (1989; as cited in Hillenbrand & Houde, 1996), this seems to be a direct result of the constriction of the glottis and of the accompanying low volume-velocity which ranges from 12 cm^3/s to 20 cm^3/s (cf. 100 – 350 cm^3/s for modal phonation) (Catford, 1977, p. 98). Moreover, numerous other features have been observed in connection with creak. These include irregular periods (Slifka, 2000; Redi & Shattuck-Hufnagel, 2001), voicelessness (Ding, Jokisch & Hoffmann, 2000; Klatt & Klatt, 1990), variability in amplitude and/or frequency (Kohler, Peters & Wesener, 2001), diplophonia, and a sudden shift from low to relatively high F0 which is then sustained

(Redi & Shattuck-Hufnagel, 2001). These cues need not occur all together and may appear in various combinations. Otherwise, different authors (see Redi & Shattuck-Hufnagel, 2001) proposed different classifications of creak-related phenomena based both on perception and observed acoustic shape, but so far, these classifications rather add to the state of confusion in terminology and do not seem to have discovered any patterns in the actual usage. The authors were generally forced to conclude that the variation in realisations was largely a matter of personal preferences of the speakers.

The preliminary reason that Redi and Shattuck-Hufnagel (2001) offered in order to explain such pervasive variation was found in individual differences in vocal fold physiology. From the perceptual point of view, the fact that listeners accept different acoustic cues to represent what in result is one function allows for greater flexibility on the part of speaker. Hillenbrand and Houde (1996) investigated this type of glottal stop manifestation in a series of perceptual tests where the salient acoustic cues (amplitude and F0 contours) were manipulated in order to learn how they contribute to the overall effect of glottal stop. The results showed that a dip in the fundamental frequency is a stronger cue than reduction of amplitude but that in most cases, to signal a glottal stop, it is sufficient if either of these cues appears alone.

At this point, a note towards the terminology used in the current study is needed. Generally speaking, the term *glottal stop* may be viewed as having two meanings: it either narrowly denotes the stop consonant described in the first section (see p. 8) or, from the functional perspective, it encompasses all the different manifestations of irregular signal described in sections 2.1 through 2.3, including the glottal stop consonant per se. These phenomena share the same set of linguistic functions which are discussed below. Because it is often useful to distinguish these meanings, throughout this paper, the term ‘canonical glottal stop’ will be used to denote the first meaning. Another terminological difficulty arises around the term *glottalization,* which is taken here as synonymous to the second meaning, i.e. glottal stop in general. In literature it is often used in this sense, as an umbrella term, but some authors prefer to define it otherwise, so caution is needed.

2.3 Breathy glottalization

Breathy voice and creak are usually put on the opposite sides of the phonation types continuum that is based on the relative constriction of the glottis. Breathy voice (also called murmur) is typically characterised by “a higher flow rate and a looser form of vibration”

(Ladefoged & Maddieson, 1996, p. 57). In its articulation, the air escapes between the arytenoid cartilages while the vocal folds are set at the maximum width still allowing for phonation (Esling & Harris, 2003). The glottal opening that is maintained throughout phonation can cause amplitude reduction in mid and high frequencies, and the appearance of a strong noise component that is believed to create the impression of breathiness (Hanson et. al, 2001). Breathy voice also very often lowers the fundamental frequency, although it is not yet clear to what extent this is universal (Pennington, 2005, p. 24).

Straightforward descriptions of breathy voice were, however, problematised by Gerratt and Kreiman (2001) who noted that breathy voice does not form "a coherent perceptual category" (p. 377). The authors regarded breathy voice as a category that is continuously (rather than categorically) different from modal phonation. By this they meant that it is possible to assess the relative degree of breathiness in a speaker's voice, unlike for example with creak, which either is present or not. They pointed out that even expert listeners may find it difficult to agree whether an utterance is breathy or not, whereas no such problems arise with creak. Moreover, there are yet no reliable descriptions of the underlying physiology and acoustics of breathiness (Gerratt & Kreiman, 2001).

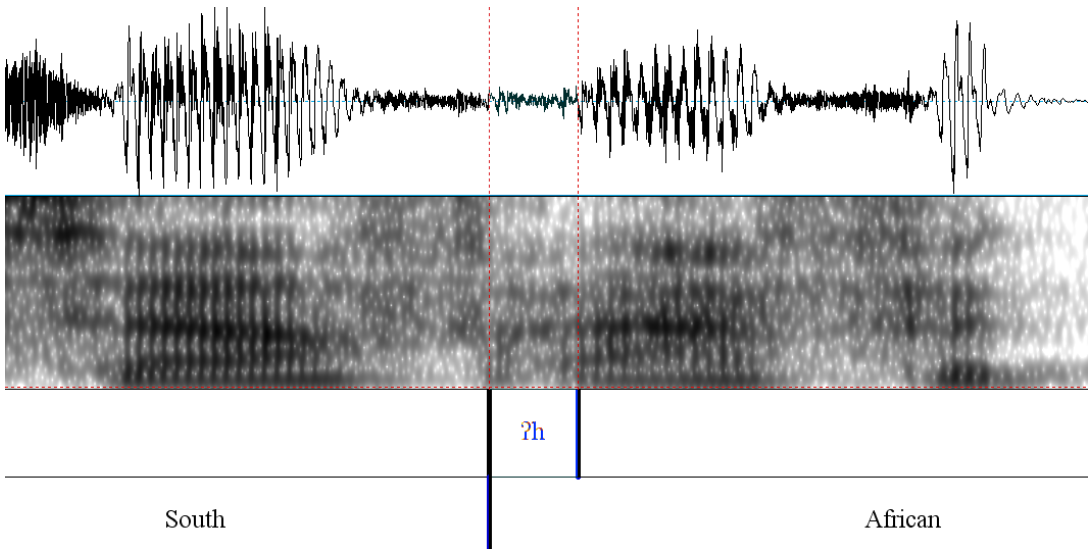

Figure 3. Breathy glottal stop.

Although it is rare, even breathy voice may appear in word onset, functioning perceptually as a glottal stop, as illustrated in Figure 3. This phenomenon is not widely reported in literature, owing probably to its marginality. In his study on glottalization in German read speech,

Jonathan Rodgers (1999) sought to explain these onsets by the influence of preceding voiceless segment or by overall breathiness in the voice quality of a speaker.

2.4 Paralinguistic functions of glottalization

Non-modal phonation and glottalization phenomena also bear sociolinguistic and paralinguistic functions. Our knowledge in this field is, however, still very incomplete. This is partly due to persisting uncertainty whether investigation in this direction belongs to the field of linguistics. Moreover, it may be very challenging to acquire suitable experimental material, especially in research devoted to expressions of affect in speech (for details, see Campbell, 2000). It is also important to be able to distinguish between results based on solid research on the one hand, and cultural stereotypes and preconceptions on the other.

Among the variables of sociolinguistic research are included age, gender and language (or dialect) of the speaker. In the first two categories, it is always necessary to determine to what extent the observed manifestations are governed by physiology and what is caused by cultural influence. Some examples follow from languages that employ non-modal phonation: It was observed that women tend to have breathier voices (Ito, 2005) while men tend towards harshness - breathy laryngealized termination was interpreted as an expression of maleness by Klatt and Klatt (1990). Ito (2005) furthermore found that breathiness is a factor contributing to politeness in Japanese speech. In some dialects, the voice quality may serve as a staple of social class, as for example creaky voice for higher social status in Edinburgh English (Esling, 1978 as cited in Gobl, 2003, p. 38). Creaky voice may also function as an expression of the speaker's attitude: it designates boredom to many speakers of English, and is used to express commiseration in the Tzeltal language (Gobl, 2003). Even from this brief example, it is apparent that this variety of opposing functions on multiple linguistic levels is a possible source of misunderstanding and, arguably, it would be better to know more about this subject. Moreover, it may also serve as a clear illustration that the picture so far is very incoherent and that the individual results are largely disconnected.

Yet there are at least two instances in the research of phonation types where the function and its manifestations are shared across languages. The two phenomena, called utterance-final and interruption glottalization, are in one of the more consistently researched areas. There are functional and acoustic differences between the two types and both are dissimilar from other instances of glottalization. Klaus Kohler (2000), who investigated these phenomena primarily

in German, found comparable tendencies in English and Romance languages, and Ogden (2001) reported a similar strategy for Finnish, which suggests that the phenomenon could be to some extent universal. These kinds of final irregularity are also of special interest for this study, because they appear to influence word-initial glottalization as well.

To hint that their turn is ending, speakers have a variety of cues at their disposal. As with other phenomena which utilise multiple cues, there is a great deal of inter- and intra-speaker variation. To express termination, speakers very often use low fundamental frequency and phrase-final lengthening. Utterance-final glottalization is then an optional marker that strengthens the other possible signals of turn-ending (Kohler, Peters, & Wesener, 2001). Janet Slifka (2000) observed three different trends in termination: regular voicing with diminishing amplitude, irregular voicing followed by a stretch of regular voicing with tapered amplitude, and irregular voicing. She found that individual speakers showed habits in termination. Her research confirmed that the final irregularity is connected to increasing abduction of the vocal folds, which is supposedly done in preparation for breathing during which the vocal folds are abducted all the time. This explains why at this transition a stretch of breathy voice might also appear (Rodgers, 1999, p. 182). Otherwise, the vocal folds in creaky voice are mostly adducted, which makes the two instances of glottalization profoundly different on the articulatory level. Redi and Shattuck-Hufnagel (2001) found that glottalization appears phrase-finally even in utterance-medial position, but to a lesser extent than at the ends of utterances. The authors distinguished several types of glottalization and found that speakers showed preferences in their use of these, but that the different manifestations did not vary systematically at different places of the utterance (i.e. utterance-medially and finally).

Similarly to final glottalization, interruption glottalization (sometimes called truncation glottalization) can also be manifested in more than one way. It is connected with turn-holding and may be triggered in various speech situations. In natural conversation, speech may be interrupted from several reasons, which include hesitations, errors, or external causes that make the speaker stop. Another distinction arises between interruptions at word boundaries and those that leave a word unfinished. The proportion of canonical glottal stops for interruption glottalization is higher than for final glottalization, especially in cases where the word is cut off. When the interruption or syntactic irregularity comes at word boundaries, non-linguistic cues like breathing are employed more often. (Kohler, Peters, & Wesener, 2001). Creaky voice is also frequent with word fragments and usually affects the last 20 to 50 milliseconds of the word (Shriberg, 1999).

2.5 Linguistic functions of glottalization

According to UPSID, a database that gathered information on phonological inventories of 451 languages, and which can be publicly accessed through Frankfurt University interface, almost half (47,9%) of the included languages feature glottal stop as a phoneme, which makes it the fifth most frequent plosive sound appearing in world languages' inventories. In several languages, the phonemic glottal stop is banned in initial onsets of various prosodic domains (Flack, 2009). As was noted above, in many languages the production of the glottal stop is often not realised canonically, and is replaced by a form of creaky voice. There are also many languages in the world that use non-modal phonation distinctively or allophonicaly on both vowels and consonants.

Another linguistic function of the glottal stop is allophonic. In some languages (e.g. English or German), the canonical glottal stop or some other form of glottalization may in certain environments replace or reinforce voiceless plosives. Different authors dubbed this as glottaling, preglottalization, glottal reinforcement or simply plosive-related glottalization. It happens either word-medially or finally and affects plosives of different places of articulation, depending on language or dialect. The phenomenon has been ascribed to socio-linguistic factors such as age, sex, or social status of the speakers (Roberts, 2006; Docherty & Foulkes, 1999), as well as to the influence of neighbouring segments, i.e. coarticulation (Huffman, 2005; Kohler, 2000).

2.6 Vowel-initial glottalization

As was already suggested, glottalization also frequently appears in the pre-vocalic position. Marzena Żygis (2010) incorporated vowel-related glottalization into a theory of consonantal insertions. A consonantal insertion is a process, whereby a sound that is not present underlyingly appears on the surface. The author distinguishes three kinds of these insertions: grammatical, phonetic and prosodic. The grammatical insertions are dependent on grammatical categories and are stable, i.e. not subject to variation. Phonetic insertions are explicable in acoustic, articulatory or perceptual terms and in this way are rather context than language-dependent. The prosodic insertions are epenthetic processes related to prosodic boundaries, among which the author counts the glottal stop as the most frequent type. Characteristic for the last group is a high degree of variability. Żygis offered a phonological explanation for the frequent co-occurrence of glottal stops and vowels in language systems.

According to her, the glottal stop provides the otherwise missing onset needed for the ideal CV syllable. Furthermore, the fact that both vowels and glottal stops lack supraglottal constriction works in favour of their appearing together.

Generally, the onset of vowels may be hard, smooth or breathy. Hard onset (see p. 9) corresponds to the presence of irregular pulses before the normal, quasi-regular vocal fold vibration of the vowel is reached. Smooth onset is the gradual increase of amplitude normally observable in sonorant consonants. Breathy onset looks almost like a short [h] prefixed to the vowel and is the least frequent of the three.

Initial vowels are treated differently in different languages. The tendencies may be seen on a scale from languages that avoid glottalization in most cases and sometimes are said to use none at all, to those that apply it so frequently that in similarly simplified descriptions, glottal stops are treated as a compulsory part of pronunciation. The research so far has showed that the situation is not so straightforward.

2.6.1 French

A typical example of the first extreme would be French, where word-initial vowels are normally linked to the previous segment. This involves resyllabification in the case of preceding consonants and hiatus in the case of two adjoining vowels. Linking, however, cannot be completely pervasive and glottal stops appear even in French. One of the most obvious places would be the utterance-initial position. The only available work focused exclusively on glottal stops in French is that by André Malécot (1975, also see Table 1, p. 24), who analysed the distribution of this segment in a spontaneous speech corpus. His methodology was in some ways different from the later works on glottalization discussed here, and the data are thus not entirely fit for comparison. What was the main tendency in French at that time is nonetheless quite apparent from the figures Malécot gave: of the glottal stops, only around 4% appeared phrase-medially (but see below), less than 20% phrase finally (truncation) and the rest, i.e. roughly three quarters of the occurrences, was found phrase-initially. This, however, corresponds to mere 56% of the utterance-initial vowels. It would be highly interesting to know what happened before the utterance-initial vowels that were not preceded by a glottal stop. Unfortunately, Malécot was concerned only with the canonical glottal stop proper and apparently ignored other manifestations of glottalization, which must have presumably appeared in the material as well. The figures and results given in the paper are thus not entirely suitable for comparison with the newer studies that include a whole range

of glottalization phenomena. For our purpose, there is one further problem with Malécot's data on phrase-medial glottal stops: both word-final and word-initial glottal stops were grouped together in the phrase-medial category, and the figures for the subgroups separately cannot be retrieved. This must be born in mind when looking at the figures: there are fewer than 4.3% word-initial glottal stops in the medial position. Kohler (2000), who commented on the vowel glottalization in French just briefly, stated that "the default word-initial vowel onset is non-glottalized. Under strong sentence accent, glottalization phenomena appear, and phrase-final laryngealization and truncation glottalization are carried over to following word-initial vowels. Glottalization phenomena around word-initial vowels can thus become a cue to phrasing. The nature of Malécot's data does not allow for direct confirmation of this proposition, but the two authors agree in that vowel glottalization in French is a marginal phenomenon, at least phrase-medially. This is supported by the findings of Fougeron (2001), who, in her study of articulatory properties of initial segments in French, found that vowel glottalization is more frequent initially and especially in higher prosodic constituents.

The principal function of glottal stops in French is emphatic, according to Malécot, who subsumed quotation form, self-repair and "calling attention to a qualification or distinction" (p. 52; probably meaning focus accent) into the category of emphasis. Nevertheless, as he acknowledged, there were numerous instances of utterance-initial glottal stops whose function could not be "unequivocally demonstrated on the basis of their lexical or grammatical context," (p. 52). What was perhaps innovative was that Malécot examined the distribution of glottal stops in relation to what he called "paralinguistic factors" (p. 55) that included sex, occupation and age of the speaker, their emotional state and intent, subject matter, loudness, syllabic rate and several other. It is apparent that some of these categories could present objective problems, as they are rather vague, or the distinctions inside the category blurred (cf. emotional state or subject matter). Many of these categories were found to have no effect on glottalization. Following is a summary of the results that were significant for utterance-initial glottal stops: Malécot found that women produced more glottal stops than men. As for age, the middle group (economically active people), whom the author considered to be the bearers of linguistic change, produced most glottal stops. Furthermore, any departure from normal voice in terms of loudness led to a drop in the number of glottal stops, while energetic speech style was characterised by a higher rate of glottal stops. No effect was found for syllabic rate and word class.

2.6.2 Czech

In Czech, the function of initial vowel glottalization is demarcative: it marks the boundary of a word (or morpheme) beginning with a vowel. Traditionally, the glottal stop was taken as a necessary part of the orthoepic pronunciation (cf. German). The gradual tendency throughout the years was to make the glottal stop largely facultative. Hůrková, who published the last orthoepic norm in 1995, recommends the use of glottal stops to professional speakers, and otherwise makes its employment obligatory only after non-syllabic prepositions (e.g. v Anglii [fʔaŋglɪjɪ]; 'in England'). In actual usage, however, the frequency of glottal stops in various environments is rather individual and there are speakers of Czech who skip the glottal stop in this context (uttering [vaŋglɪjɪ]), while retaining it elsewhere. Whether the changing attitude found in the norm actually reflects the usage, i.e. whether the glottal stop is used less and less in Czech, is putative. Rather, it seems to be a matter of the speakers' individual preferences. As the use of glottal stops adds to intelligibility, it is preferred in formal situations and appears more frequently in slower speech rates and emphatic speech style (Pavelková, 2001). This also corresponds to the findings of Ding, Jokisch and Hoffmann (2006) who reported that the frequent use of vowel glottalization is a factor positively influencing the listener's preference of a speaker. In a recent study by Volín (2012), higher rates of glottalization were found for read speech, as opposed to semi-spontaneous dialogues. Differences were also found between men and women with women employing glottal marking more often.

2.6.3 German

Older descriptions of German state that all initial vowels are canonically realised with a glottal stop. Jonathan Rodgers (1999, also see Table 1, p. 24) (expanding on Kohler, 1994) criticised the previous treatment as simplistic and prescriptive and problematised the whole issue in his work, where a comprehensive treatment of truncation and plosive-related glottal phenomena may be found in addition to vowel-initial glottalization. Rodgers examined read as well as spontaneous speech of both professional and non-professional speakers in the Kiel Corpus. In this rich material he observed the frequency and realisation of glottal phenomena in relation to speech style, word class, position in utterance and sentence accent, taking into account the possible interactions of these factors. As concerns the different realisations, the following four classes were distinguished: glottal stop, glottalization (creaky voice) with and without glottal stop, and absence of glottal marking. In his terminology, the author distinguishes glottal stop (canonical) and glottalization (the ensemble of other realisations).

The study largely confirmed Rodgers' hypotheses: because read speech tends to be more careful, more glottal stops and glottalization appear there. The examination of various interactions between the factors showed that canonical glottal stops in particular are typical for read speech. In spontaneous speech, it is more common to encounter words with no glottal marking, and glottalization (creaky voice) is more preferred than canonical glottal stops. The effect of word class was also highly significant, with some kind of glottalization appearing with 90% of content words and only 40% of function words. This is explained by the lack of semantic importance and an ensuing lack of prominence in function words. Vowels in utterance-initial position were usually preceded by a canonical glottal stop, whereas those in medial position were more often marked by creaky voice or nothing at all. The influence of accent is also striking – only a quarter of the unaccented vowels appeared with some kind of glottal reflex, while conversely, almost all of the accented vowels had glottal marking (p. 196). Furthermore, a highly significant interaction between accent and position was observed. Even unaccented vowels were likely to bear some glottal marking when in initial position (77% vs. 57% in medial position), which could suggest the strength of the factor of position. On the other hand, accented words appear without a glottal reflex more often in the initial position (12% vs. 4% in medial).

It can be seen from these results that the reality is by no means as straightforward as was traditionally presented. The problem lies not only in the fact that not all word-initial vowels in German are accompanied by a glottal segment, but also that there are some patterns or tendencies as for the particular realizations thereof. As Rodgers noted, some previous descriptions of German completely ignored the importance of creaky voice, although in spontaneous speech it is even more frequent than the canonical glottal stop. The findings of Rodgers and Kohler are in line with the research undertaken for American English (see p. 22) in recent years.

Pompino-Marschall and Żygis (2010) also investigated vowel-initial glottalization in German. Nevertheless, their choice of material was strikingly different from that in other studies on this topic, in that it consisted of public speeches made by three prominent German personalities. The majority of these were recorded before 1950. The authors did not explain this choice, e.g. why they chose these particular speakers or what advantage they saw in having such old recordings for the purpose of describing contemporary language. Neither did they clearly state whether the speeches were read or not (assumably they were). From the description and comments provided by the authors, the material seemed rather heterogeneous

in its form, which the authors had to take into consideration and which made comparison and generalization of the results more difficult. All the measurements were related to speech rate and the analysis itself was based on quartile ranges, thus giving four levels of speech rate. The effect of speech rate on glottalization was not studied specifically in any of the available papers on the subject, apart from Malécot (1975), who found no relation. In the study by Pompino-Marschall and Żygis, speech rate was presented as a parameter superior to all the others. The authors, however, never explained why this should be so, nor did they come with a clear hypothesis. It could have been expected that faster speech rates would cause a drop in the frequency of glottalization. The logic behind this draws on the findings of Rodgers (1999) who connected a higher rate of glottalization with the more careful pronunciation of read speech. This could be reasonably extended to the relative carefulness of slow versus fast speech. A similar proposition is found in Pavelková (2001) for Czech.

The authors indeed observed higher rates of glottal stops in the slowest quartile and a tendency towards no marking in the fastest. The preference of creaky glottalization was slightly higher in the two faster rates. Next, the factors of word class, utterance position and vowel height were examined in relation to speech rate. In content words, the ratio of unmarked items to all glottalized was fairly stable. When the categories were separated according to glottalization type, there was a preference for creak to canonical glottal stops in the faster half of utterances. This means that with growing tempo, canonical glottal stops would first be replaced by creaky glottalization and then the marking would be lost altogether in content words. As for function words, the amount of the unmarked ones rose from 37% in the slowest quartile to 66% in the fastest (p. 11). The authors noted that this proves that content words are more resistant to losing the glottal marking. A similar tendency was found in stressed words, although the results were not as clear, which was attributed to a smaller number of tokens.

All of the above-mentioned findings of Pompino-Marschall and Żygis were more or less in line with the results of previous research. What was surprising and contrary to the results of various earlier probes in several languages (e.g. Rodgers, 1999 for German; Dilley et al., 1996 for American English; Jogenburger & Van Heuven, 1991 for Dutch), was the finding that the effect of position in phrase was “weak, i.e. only visible at slow medium rate” (the second quartile; p. 12). According to the presented data, no marking prevailed in the two faster speech rates, independent of position. In other words, the canonical glottal stop was prevalent in initial position for the two slower rates, but 50% and 57% of phrase-initial vowels in the

two faster rates bore no marking. No interpretation was given for this anomaly; neither did the authors reveal how many tokens they had and whether this could not be caused again by insufficient sample. Furthermore, when we look at the data, we can see that the proportion of canonical glottal stops in the phrase-initial position was still higher than for all the other examined cases, and that creaky glottalization barely appeared in this position at all. Consequently, the difference did not lie that much in the scarcity of canonical glottal stops, but rather in the fact that the use of creak in initial position was clearly avoided for all the speech rates. In this, the data agree with Rodgers (1999), who observed that canonical glottal stops tend to be more frequent in the phrase-initial position, while creaky glottalization in the medial, as was already mentioned above (p. 20). In the two faster rates, creak was restricted in favour of no marking, which is only logical, considering the general effect of speech rate found by the authors themselves, which was shown to disprefer glottalization in fast speech.

2.6.4 American English

For the purposes of speech synthesis, Ding, Jokisch and Hoffmann (2004) investigated glottalization in three languages, one of which was American English. They concluded: “In analyzing the speech database from 6 US-English speakers, we found it impossible to generalize a particular pattern for their occurrences. Actually, glottal stops can be found anywhere in an utterance. The frequency of the occurrence varies from speaker to speaker.” (p. 39). While it is true that glottalization in English is a rather idiosyncratic phenomenon, there are several studies that show that its characteristics are to some extent comparable to those found in German and that there are some general tendencies in its incidence.

The study of Dilley, Shattuck-Huffnagel and Ostendorf (1996, also see Table 1, p. 24) focused on the segmental and prosodic influences on word-initial glottalization. The team examined a prosodically-labelled corpus of read news stories produced by five professional speakers. Their goal was firstly to ascertain whether the previous finding of Pierrehumbert and Talkin (1992) that vowel-initial glottalization is more likely to occur in prosodically prominent locations was confirmed in their corpus, and secondly, whether the strength of prosodic phrase had an effect on glottalization. Thirdly, they wanted to find out whether there was an influence of pitch accent on the rate of glottalization. Lastly, the authors investigated the effects of the immediate context preceding the target vowel.

For a token to be considered as glottalized, it had to be perceived as such both aurally and visually. The irregularity in waveform that was necessary for the visual classification was

most often manifested as irregularly placed periods and sometimes, usually between two vowels, as a dip in the fundamental frequency. One of the five speakers also frequently employed a dip in amplitude that was perceptually equal to glottalization, and mostly appeared at the same places where the other speakers glottalized. The authors suggested that the amplitude dip might belong to the same family of gestures as the irregular pitch periods, referring there to the conclusion drawn by Hillenbrand and Houde (1996) who experimented with synthetic stimuli and found that a dip in amplitude was enough to signal glottalization (see p. 12 here).

The results of Dilley and colleagues confirmed the previously found connection between prosody and glottalization. Despite the pronounced differences between them, all speakers glottalized significantly more at the phrase-initial position, even when the phrase did not come first in a full intonational phrase. In order to eliminate the influence of pause or glottalization on the preceding segment, the authors examined a subset of phrases that excluded this context, and the effect was found to be strong even then, although to a smaller extent. The presence of pitch accent increased the likelihood of glottalization, especially for the non-phrase-initial position. There was also a difference between reduced and unaccented full vowels, observed especially in phrase-initial position, where the rates were higher for the full vowels. Lastly, even accent appearing later in the word (as in “obTAIN” or “OcTOber”, where the initial vowel is reduced and full respectively), had an impact on the presence of glottalization.

As was implied above, the preceding pauses and glottalization had a very significant effect on the occurrence of glottalization. The authors proposed two explanations for this co-occurrence: it was either a consequence of mechanical constraints of the vocal tract in this specific context, or a prosodic feature, as 92% of the glottalized items appear at a phrase boundary. The second explanation was favoured, because it was not solely after pause or word-final aperiodicity that speakers glottalized the initial vowels. A preceding vowel also boosted the chance of glottalization, but the effect was slighter. Otherwise, no other as significant influence stemming from the preceding segmental context was found. The authors consider glottalization to be an actively produced marker of prosodic boundaries. The results were later replicated for German read and spontaneous speech by Rodgers (1999, see above).

From the studies described above, it is apparent that vowel-initial glottalization is a phenomenon appearing in connection with prosodic marking. Glottalization rates are highly subject to intra- and inter-personal variation and are thus difficult to explain. Apart from prosody, semantic factors were proven to be important on German material. Table 1 overleaf provides an overview of the findings of three of the representative studies that were discussed above in detail.

Table 1. An overview of the results of three of the bigger studies on word-initial glottalization.

Language	Speech style		Position		Word class		Prominence		Gender	Syllabic rate	Favourable context	No. of tokens; notes
	Read	Spontan.	**Initial**	Medial	Content	Function	**Accented**	Unaccented				
German (Rodgers, 1999)	**74%**	66%	**80% S: 82%; R: 79%**	68% S: 60%; R: 74%	**90% S: 89%; R: 90%**	60% S: 56%; R: 64%	**94% S: 93%; R: 95%**	75% S: 56%; R: 66%				7734 spontaneous; 4602 read
French (Malécot, 1975)	Only spontaneous		**76,90%**	4,3% (wd-final + wd-initial)	Found no effect				Females more	Found no effect		3964 vowels in phrase-initial position
US English (Dilley, 1996)	Only read		**+**	-			+	-			Preceding pause / glottal	3709 vowels

Note: Fields in grey were not considered in the given study. The "+" and "–" sings are used to symbolize greater and lesser rates where exact numbers could not be retrieved. *S* and *R* stand for Spoken and Read speech.

3. Method

3.1 Material

Speech of ten non-professional speakers (referred to below as the corpus) was analysed for the present study; the sound material forms part of the Prague Phonetic Corpus (Skarnitzl, 2010). The speakers, five male (KPXN, OFXN, PDXN, SSXN, TJXN) and five female (AHAN, AWAN, KLAN, SAAN, VSAN), were native speakers of English, coming from the south of England. All of them were university students or employees, their ages ranging from 20 to 45 years. Each participant was asked to read a news bulletin that had been retrieved from a 2002 BBC broadcast. The radio programme usually consists of seven pieces of news and three framing calls, such as 'BBC news'. The recordings are normally about four minutes long. The speakers were recorded individually in a sound treated room with high quality equipment, and had enough time to get familiar with the texts before they read them on the microphone. There are seven different news texts appearing in the corpus; namely, five speakers each read a different variant and of the five remaining, three and two speakers shared the same text.

3.2 Procedure

The material was handled in the following way: the news sessions were first cut into their constituent news pieces, or paragraphs. Subsequently, the paragraphs were cut into individual breath groups; that is, sequences delimited by pauses for inhalation. Apart from that, to qualify as a breath group, a sequence had to be at least 1.2 seconds long. Shorter distances between breaths were often caused by hesitation, speech disfluency or a previous overlong stretch of speech. In these cases, the shorter sequence was included in the preceding breath group. Further exceptions, where inhalation appeared inside a breath group, were made in cases where the breath happened to separate two syntactic units that were semantically tightly connected (as in restrictive apposition, e.g. Augusto {breath} Pinochet). The two parts were left together even if by themselves they were long enough to constitute individual breath groups. All instances of false starts or hesitation that would be separated by a breath or pause and then fully repaired were disregarded and not included in the analysed materials.

Using the Praat program (Boersma & Weenink, 2012) the breath groups were annotated with orthographic transcription and vowel-initial words were hand-labelled. When all the relevant words were thus properly identified, their initial vowels, glottalization phenomena and final segments of preceding words were marked. Before proceeding further, two points have to be made for the category of vowel-initial words. Firstly, it excludes special cases like weak forms of personal pronouns that lose an initial consonant, as in 'his' pronounced [ɪz]. Secondly, the character of the text, i.e. world news, had some implications for the lexis of the corpus, one of which was the presence of many acronyms. Another one, namely the relatively high concentration of foreign proper names, is considered below because it had no direct effect on the labelling process. The acronyms, however, had to be accounted for at the stage of labelling. The texts included thirteen different acronyms (58 occurrences in total), four of which (12 tokens) were read as words, while the rest was spelled out. It was decided that both these types of acronyms would be considered as single words. In other words, only the initial vowels of acronyms were analysed even if they included a vowel element in other than initial position (e.g. FBI).

At the beginning, 1307 vowel-initial words were identified, of which 168 items had to be discarded, leaving the total of 1139. The discarded items included 12 disfluences (7 for speaker AHAN), 16 words that were realised without the initial vowel, as in 'about' pronounced [baʊt], and 140 words that followed a pause. This last category was omitted from the analysis on the presumption that the effect of full intonation phrase is very strong and it is rare not to find any glottalization in this context. (Dilley, Shattuck-Huffnagel, & Ostendorf, 1996, p. 436). Indeed, 134 of these words were glottalized. The remaining six vowels had the soft beginning (see p. 9) and were in five cases produced by speaker AHAN.

3.2.1 Segmentation

The judgement about presence or absence of glottalization was first and foremost based on the criterion of salient perception. This decision naturally followed from the conviction that glottalization is a strategy with specific functions aimed at the hearer. Thus, the occasionally appearing non-modal phonation at the beginnings of words that did not function perceptively as a glottal stop was not labelled as such. Usually, instances of these appeared in generally creaky surroundings. To determine the exact boundaries of glottalization, both visual and auditive cues were taken into consideration. The general guidelines for segmentation were based on Machač and Skarnitzl (2009, p. 130) in whose view all the aperiodic pulses, or those

that are markedly different from what follows or precedes, should be included in the glottal segment.

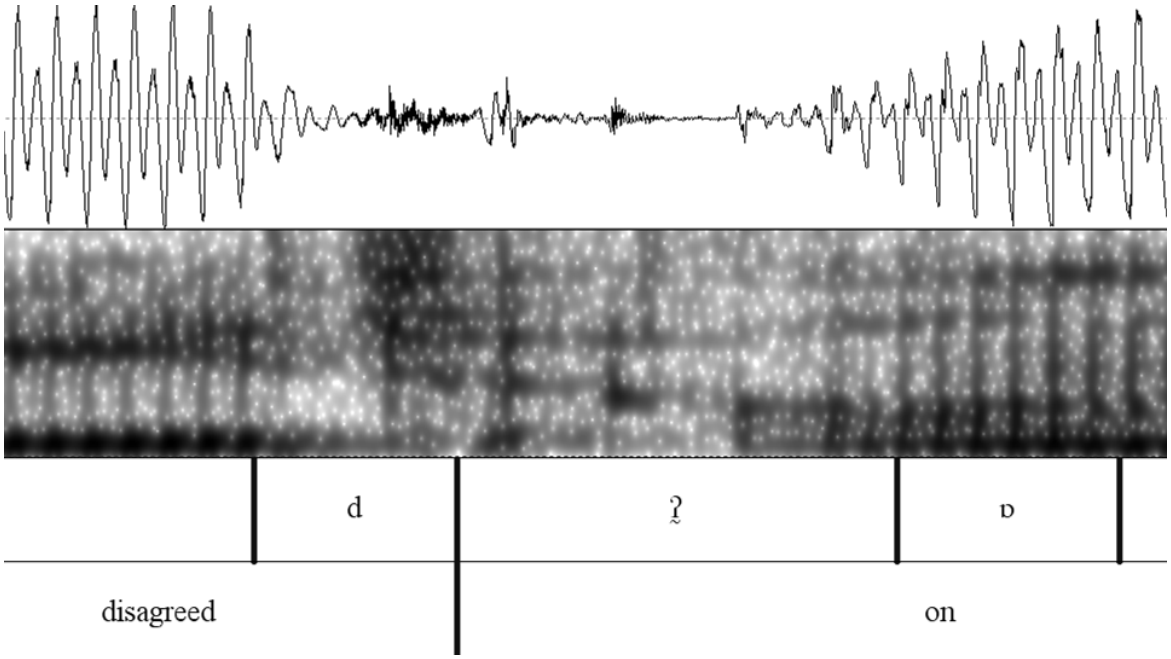

Figure 4. An example of a borderline glottal stop that features both low-amplitude friction and irregular pulses throughout. It was assigned into the "creaky" category based on the dominant auditory impression (see text).

For the sake of conducting manageable research, three coarse categories were set up that, while not being perfectly homogeneous, are differentiated enough among themselves. Nonetheless, it has to be born in mind that the huge variability of the studied phenomenon does not allow for a clear-cut classification. Naturally, there occurred borderline or intermediate cases that had to be assigned to a category despite their disputable status. These unclear cases were consulted with an experienced phonetician and very often, where the features were mixed or overlapping, more importance was attached to the overall auditive impression, as in Figure 4. The three types of glottalization distinguished were: canonical, creaky and breathy. The criteria for their segmentation are as follows:

Canonical glottal stops (see section 2.1) consist of a silent closure followed by a burst. The beginning of the closure was determined by the position of the glottal stop. If it occurred at the beginning of a breath group, it was arbitrarily set 40 to 70 milliseconds before the explosion, which approximately corresponds to the duration of glottal stops in utterance-medial position (Machač & Skarnitzl, 2009: 132). After a pause, the situation was similar. Pause was defined as silence of minimal duration of 100 ms. Shorter silent intervals preceding

a glottal stop were taken as being part of the stop, resulting in closures much longer than the average 40 to 70 ms. Irregular periods at the end of the preceding segment were considered part of the stop (so-called *barbell glottalization*, Skarnitzl, 2004, as quoted in Machač & Skarnitzl, 2009). The right boundary was identified with the beginning of regular vowel pulses. Beside this, a sudden change in amplitude could serve as a strong cue: the end boundary of glottalization could be marked by either relatively lower or higher amplitude.

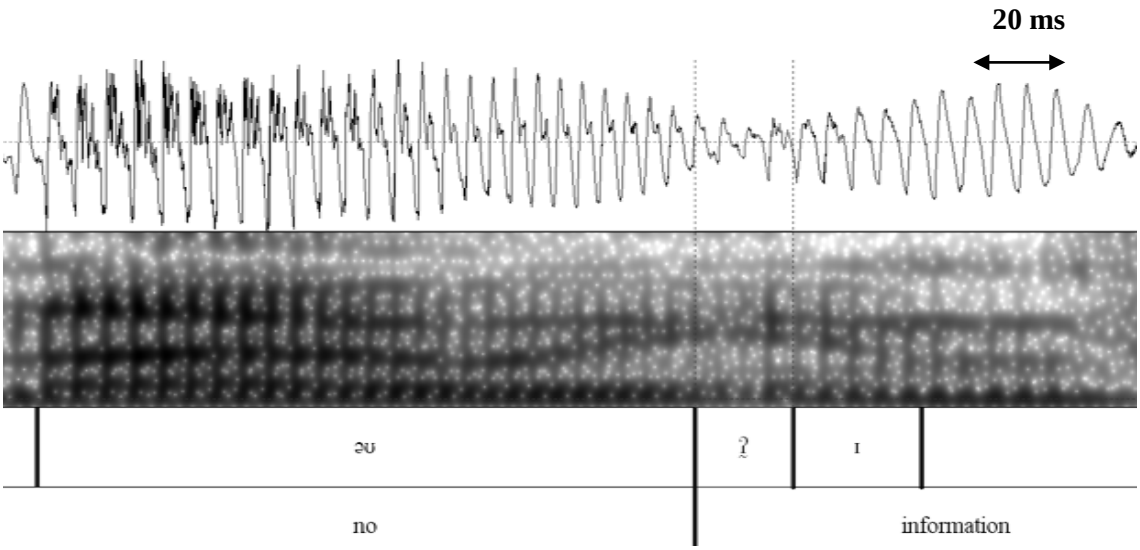

Figure 5. Low amplitude as a realisation of creaky glottalization.

Creaky glottalization was defined as consisting of irregular pulses from at least two thirds of its duration, or as having comparatively low amplitude throughout (see Figure 5). The first irregular pulse was understood as the beginning of glottalization. In many cases, these irregular pulses bore the perceptual traits of the preceding speech sound, although they were prominently rough. The segmentation was thus in these cases in the first place based on visual inspection. The same situation occurred at the other boundary of creaky glottalization, where sometimes, particularly in the case of following unstressed vowels, the whole of the segment was irregular. In such situations, a minimal portion of the vowel was spared and the rest was labelled as glottalization. As Machač and Skarnitzl (p. 130) pointed out, the considerable shortening of vowels is a certain disadvantage of this approach to segmentation and it should be taken into consideration especially in studies concerned with temporal characteristics.

Breathy glottalization was manifested as low-amplitude glottal noise, a very soft [h] sound. As is common in glottal fricatives, the continuation of the formants of the surrounding sounds was usually visible in the noise. The glottalization was labelled from the beginning of the

friction to the beginning of the full formant structure of the following vowel. Even this category was considerably variable and in many cases, the auditive impression played an important role in decision-making (see Figure 4 above).

3.3 Problem areas

Phrase-initial and final segments always present a difficulty regarding the precise placement of boundaries. It is impossible to determine where exactly the speaker started or ended articulation, especially when dealing with an initial closure. The boundaries are thus necessarily only approximate. Another difficulty arose where creaky phonation spilled over major portions of several segments, which was often due to termination phenomena. In final segments of an intonation phrase there was often a stretch of creaky phonation that gave a very strong impression of it being mainly an effect of the termination. On the one hand, it usually clearly bore the perceptual characteristics of the final segment, but simultaneously, in contexts with a following vowel-initial word, it functioned as a glottal stop. As there is no unambiguous method so far of acoustically distinguishing glottalization related to utterance-finality and that caused by a following vowel-initial segment, and because glottal stops are

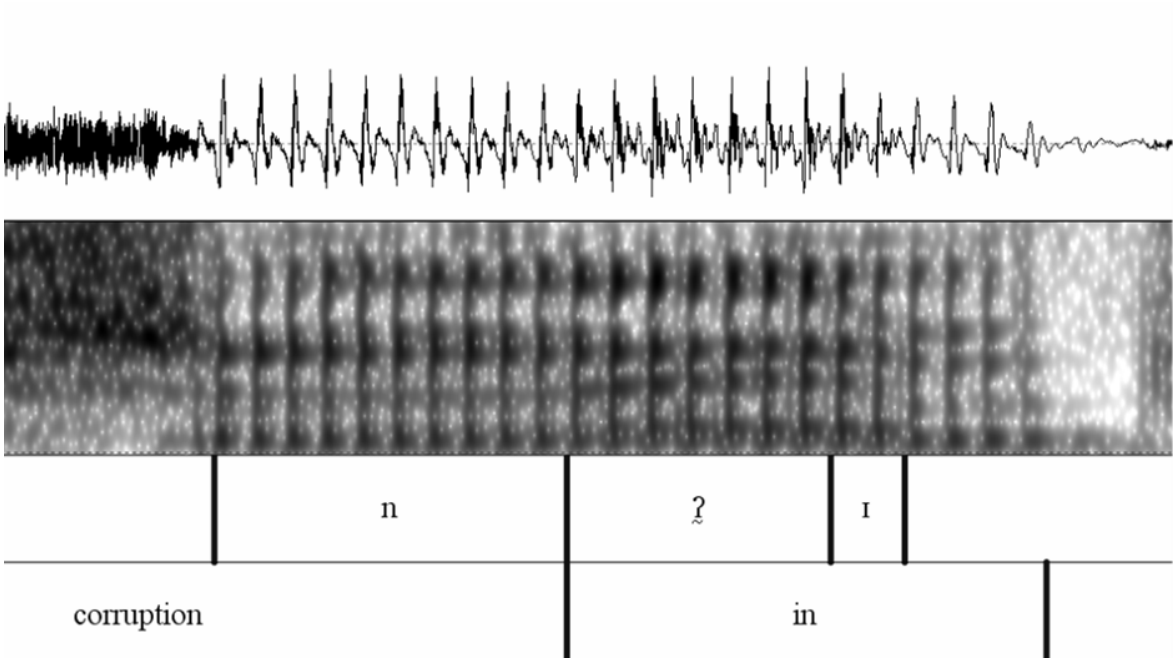

Figure 6. Prolonged creaky phonation at the end of an intonation phrase. The glottal stop is delimited by the points where change is most manifest, here best observable in the oscillogram.

thought to be connected with prosody, the whole of the aperiodic section was labelled as creaky glottalization. This means that no attempt was made to differentiate between the two kinds of glottalization. As Figure 6 shows, it would be unwise to follow the general rule specified above, in similar situations, and label all aperiodicity as glottalization. The boundary is thus situated in the place of maximal acoustic change. The problematic instances of this kind usually have the greatest impact on the duration of the segments in question, not their identity, and thus do not present a great setback for a study that is not concerned with temporal issues.

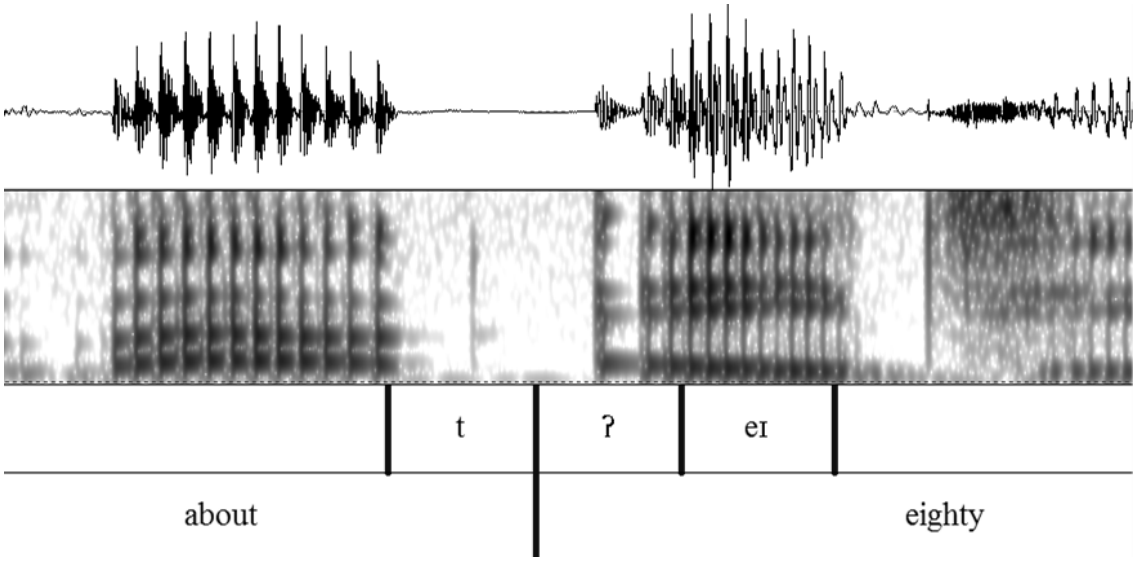

Figure 7. The interference of a glottalised plosive with a stressed initial vowel often resulted in a single canonical glottal stop with a prolonged closure (here 110 ms). See text for commenary on segmentation.

Another problem was posed by the interference of onset and plosive-related glottalization. The latter, sometimes also called t-glottaling (see p. 16 above), designates the substitution of a voiceless plosive by a glottal stop. Although /t/ is most often affected, the phenomenon is not limited to it. In the present corpus, one speaker replaced also /p/ and /k/. When an initial vowel co-occurs with word-final plosive glottalization, the result is most often a canonical glottal stop, in many cases with a very long closure, as can be seen in Figure 7. Because neither an extra long closure, nor a complete elision of a prevocalic consonant seem very likely for English, the following guidelines were devised for solving these situations: first, if the vowel is unstressed, the glottal stop is marked as a substitute for the plosive and thus forms part of the first word. No glottalization is marked. Second, when the vowel is stressed

and the closure is longer than 50 ms, or when there is a prosodic boundary, the segment is divided equally into two parts, one for the plosive and the other for initial glottalization.

3.5 Analysis factors

3.5.1 Word class

All words were assigned either in content or function word class. Content words have lexical meaning, whereas function words help to express grammatical relationships. It is hypothesised, according to Rodgers' (1999) findings that also in English, content words will be more likely glottalized. The conceivable reasons for this lie rather in the more global characteristics of the two classes, e.g. the fact that function words tend to be unaccented, which seems to be in an opposition to the reinforcing character of glottalization. Further procedures that stem from the design outlined here are described at the appropriate place in the Results section (p. 33).

3.5.2 Accent

Pitch accent is tied with prosody, hence it is likely to be a very strong factor influencing glottalization. The impact of pitch accent on the presence of glottalization has already been established in several papers (Rodgers, 1999; Dilley et al., 1996; Jogenburger & Van Heuven, 1991). In the present study, the words were divided into two categories according to accent on the first syllable: accented and unaccented, as it was realised by the speaker. Furthermore, based on the results of Dilley et al., within the unaccented category, words containing stress were treated separately to see whether the presence of pitch accent on other than initial syllable had an effect, and whether the conclusion of the American study can be confirmed.

Statistical analyses were conducted using the R software package (2012).

4. Results

4.1 Raw results

An overview of raw data is presented in Table 2, including the items that were not analysed (see p. 27 above for explanation). The heading 'initial' refers to the excluded category of words following a pause or breath, 'medial' then to the rest. It is worth repeating here that the initial position is a very strong factor with 96% of items glottalized, compared to 40% average rate of glottalization for medial words.

Table 2. An overview of the data including items not analyzed. In the last row, relative frequencies for the sums are given. The numbers in brackets give the percentage of glottalized items within the initial or medial category.

		Not Analyzed				Analyzed	
Speaker	Total	Disfluency	No Vowel	Initial (Total)	Initial (Glot.)	Medial (Total)	Medial (Glot.)
AHAN	110	0	4	14	9	92	42
AWAN	128	0	1	15	15	112	49
KLAN	111	0	3	8	08	100	58
KPXN	135	0	1	13	13	121	18
OFXN	130	3	1	15	15	111	35
PDXN	130	1	0	17	17	112	43
SAAN	151	0	1	15	15	135	58
SSXN	147	0	1	24	23	122	77
TJXN	130	1	4	5	5	120	42
VSAN	135	7	0	14	14	114	35
Total	1307	12	16	140	134	1139	457
%	100	< 1	1	11	10 (96)	87	35 (40)

As was already noted above (p. 24) and found in other studies on the subject, the overall rate and use of the different types of glottalization varies substantially from speaker to speaker. The same is true for this study, although there is room for rough generalization. It can be said that seven out of the ten speakers glottalized approximately in between a third and a half of

the cases. (See Figure 8 for details.) The three remaining speakers, KPXN, KLAN and SSXN, were most unlike the rest, although apart from the more extreme rates of glottalization, they do not seem to differ systematically in any other way. The results of Chi-Square test of independence conducted to see whether the differences in the individual rate of glottalization for all speakers was above the chance level, were highly significant [χ^2 (9, n = 1139) = 83, p < 0,001].

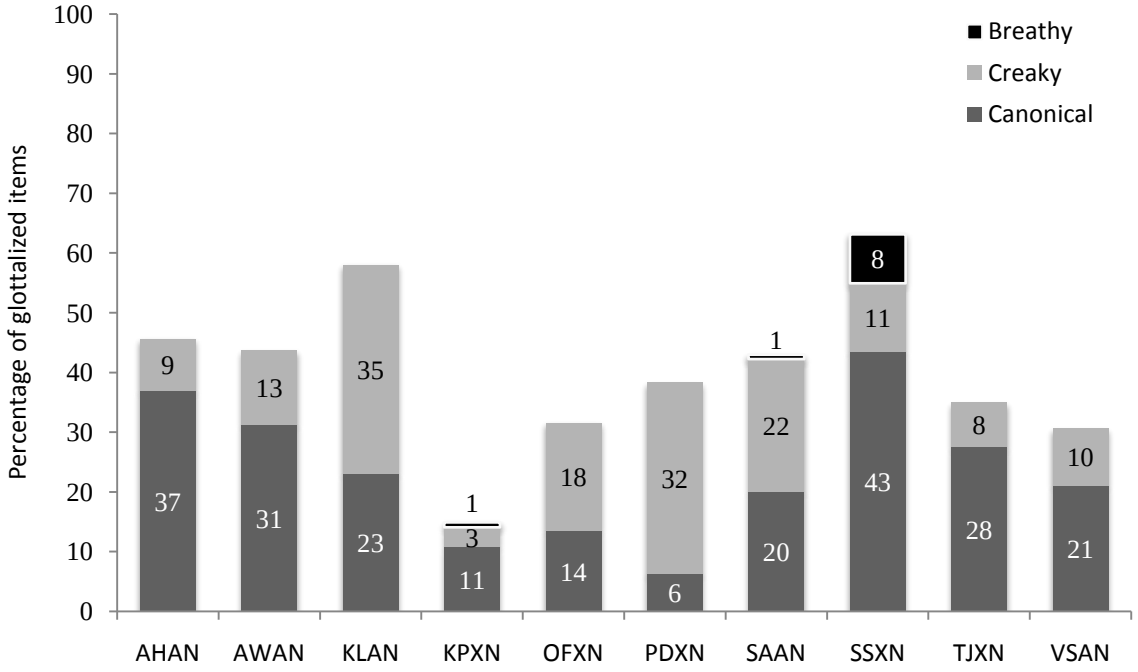

Figure 8. Relative overall rate of glottalization for individual speakers showing relative contributions of different glottalization types.

As for the three types of glottalization we distinguished (refer to Table 3 for absolute counts, Figure 9 for proportions in the analyzed subset**,** and Figure 8 for relative frequencies for individual speakers), the canonical glottal stop was the most common (58% of glottalized items), followed by creaky glottalization (39% of glottalized items). It is clearly visible that the occurrence of breathy glottalization in the corpus is rare (3% of glottalized items, 1% when vowels without glottalization are included), even if we account for the fact that almost half of breathy glottal stops (10 tokens) were found in the post-pause, hence discarded, position. In fact, the inclusion of these items would not make much overall difference, since five out of the ten discarded words were produced by SSXN, who in any case remains the only speaker for whom breathy glottalization is not negligible (8% of all his glottalized tokens).

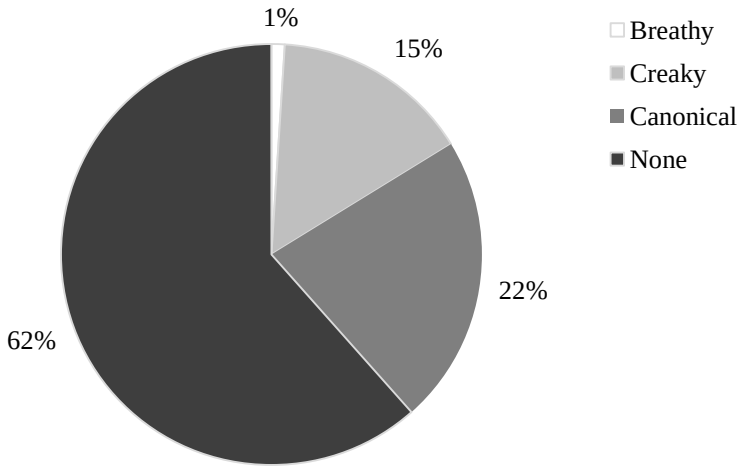

Figure 9. Distribution of the three kinds of glottalization in the analyzed sample.

Table 3. Breakdown of the Medial (Glot.) category (see text and Table 2), showing the absolute counts of the three glottalization types. For relative frequency, see Figure 8.

Speaker	Medial (Glot.)	Canonical	Creaky	Breathy
AHAN	42	34	8	0
AWAN	49	35	14	0
KLAN	58	23	35	0
KPXN	18	13	4	1
OFXN	35	15	20	0
PDXN	43	7	36	0
SAAN	58	27	30	1
SSXN	77	53	14	10
TJXN	42	33	9	0
VSAN	35	24	11	0
Total	457	264	181	12
%		58	39	3

Due to the insufficient size of the sample, breathy glottalization had to be omitted from statistical analyses. The ratios of canonical and creaky glottalization were not the same for all the subjects, as there were four speakers in the sample who employed creaky glottalization more often than the canonical form, although in two cases (OFXN and SAAN) the difference was rather small.

4.2 Word class

Traditionally, two semantic categories are distinguished: function and content words. In the material, there were 693 function and 446 content words with word-initial vowel suitable for analysis (see Table 4 for details on individual speakers). Looking at Figure 10, it may be observed that although the percentage of glottalization is higher for content words in all but two speakers, the differences in rates of glottalization between the two categories are not too dramatic, save for two or three exceptions. Statistic analysis showed significant results [χ^2 (1, n = 1139) = 9.2, p = 0.002] for the data pooled from all speakers. Nevertheless, considering individuals, the difference in glottalization of the two semantic groups was statistically significant only for AWAN [χ^2 (1, n = 112) = 7.2, p = 0.007] and marginally significant for KLAN [χ^2 (1, n = 100) = 3.5, p = 0.06].

Table 4. Absolute counts of function and content words for individual speakers: total and glottalized items.

Speaker	Function		Content	
	Total	Glot.	Total	Glot.
AHAN	61	26	31	16
AWAN	65	21	47	28
KLAN	67	34	33	24
KPXN	69	9	52	9
OFXN	64	16	47	19
PDXN	66	26	46	17
SAAN	88	34	47	24
SSXN	69	44	53	33
TJXN	70	23	50	19
VSAN	74	20	40	15
Total	693	253	446	204

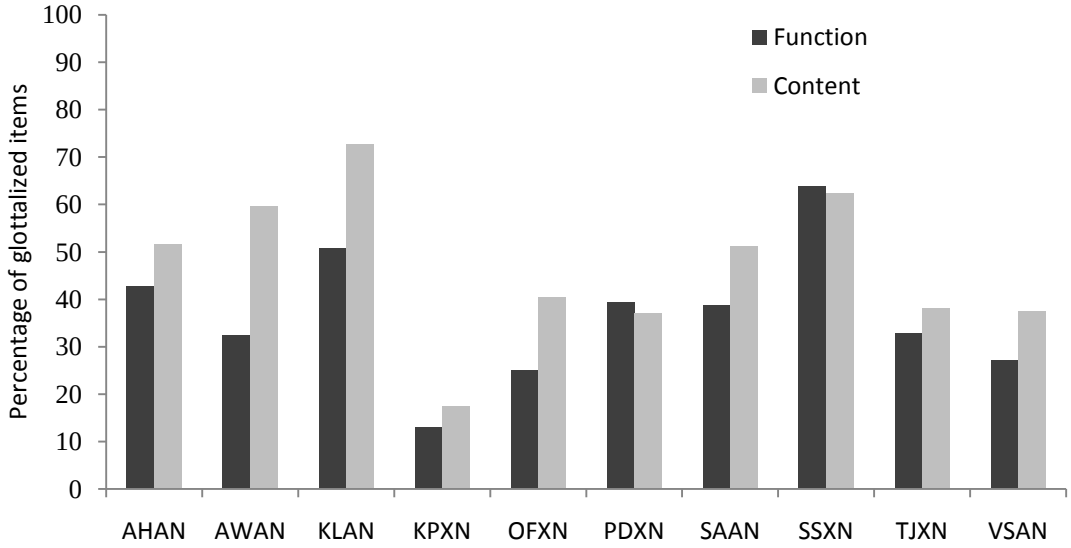

Figure 10. Relative frequency of glottalization for individual speakers, comparing function and content words.

Listening to the recordings alone led to the impression that proper names, especially the uncommon ones and those of foreign origin, make the speakers stumble, or pronounce them with more precision or even emphasis, hence candidate for glottalization. Based on this impression, a third category for proper names was recruited from content words (see Figs.Figure **10** andFigure 11 for comparison). Although the proper names group had considerably higher overall rate of glottalization and the between-group differences were highly significant [χ^2 (2, n = 1139) = 17.1, p = 0.0002], it should be emphasised that the new group was not particularly numerous (101 words). Hence it has to be added towards the visualisation in Figure 11 (overleaf) that speakers AHAN, AWAN, KLAN, PDXN and VSAN each contributed less than 10 items, which necessarily makes the results less valid.

Inside the proper names group, there seemed to be a further level of differentiation. Many words in this category were very frequent and familiar names (e.g. England); the heightened rate of glottalization, however, was especially apparent in words that were probably used less by the speakers (e.g. Ankara), or conceivably, were entirely new (e.g. Ecevit). In other words, the presence of glottalization was possibly not primarily a question of a word being a proper name or not, but rather of its familiarity to the speaker. To check this impression, the proper names were divided into two categories, according to their presence or absence in a pronunciation dictionary, since there is no purely objective way to assess which words are

novel to a particular speaker. Longman Pronunciation Dictionary (Wells, 2004) and Cambridge Pronouncing Dictionary (Jones, 2003) were used for this study. Words not included in the dictionaries were to be considered unfamiliar for the purpose of this study.

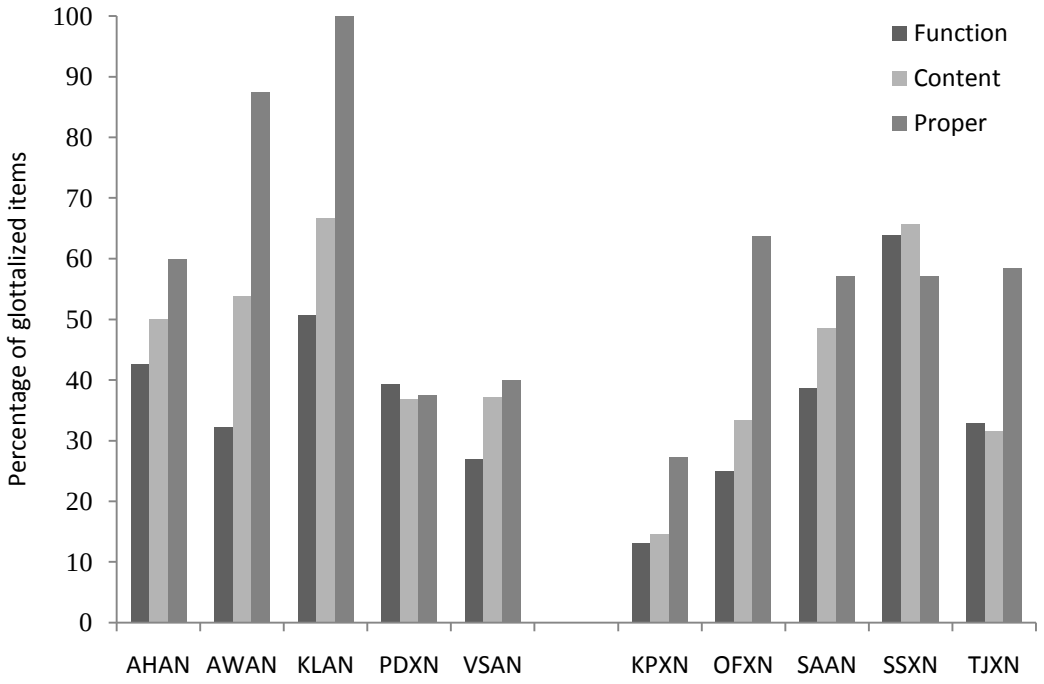

Figure 11. Relative frequency of glottalization in three word-class categories. On the left are speakers who contributed less than 10 proper names each.

The same set of words was missing from both dictionaries, which suggests that their status in English is not very well established. The difficulty that arose after taking these steps, however, was that an unexpectedly high number of the proper names did have an entry in the dictionaries, thus leaving the 'infrequent proper names' group very small (7 items, all glottalized). Further analysis in this direction was thus rendered impossible with the current sample.

The last remark under this heading concerns the effect of removing the proper names from the content words group. The test for difference between function and content words alone did not by far yield such good results [χ^2 (1, n = 1139) = 3.05, p = 0.08] as the previous one, where proper names were included within the content words category (see p. 37 above). This shows that content and function words tend to behave in a rather similar fashion, dissimilar to proper names.

4.3 Accent

The words were first divided into two categories relating to accent on the first syllable: accented and unaccented (see Table 5 for absolute counts).

Table 5. Absolute counts of items in the Accented and Unaccented categories.

	Accented		Unaccented	
Speaker	Total	Glot.	Total	Glot.
AHAN	28	10	93	7
AWAN	33	20	87	22
KLAN	25	15	89	20
KPXN	28	17	83	18
OFXN	33	23	102	35
PDXN	30	20	82	23
SAAN	23	21	69	21
SSXN	26	25	86	24
TJXN	28	27	72	31
VSAN	26	21	96	56
Total	280	199	859	257

As Figure 12 clearly shows, and Table 6 confirms (see overleaf), the effect of accent is very strong. The only speaker for whom the results were not so persuasive was SSXN, whose glottalization pattern was very balanced also in the previous analyses (see Figs.Figure **10** andFigure 11 above for comparison).

The ‘unaccented’ category was further divided into two subgroups: ‘no accent’ and ‘non-initial accent’ to see, whether the presence of accent in the word plays a role even if it is not on the target syllable. The two subgroups respectively refer to words that received no lexical stress, which was predominantly the case of monosyllabic function words, and those where other than the first syllable was accented (e.g. interNAtional). Dilley et al. (1996) found this was an important factor, although not for individual speakers. In the American study, words with accent appearing later in the word were glottalized more often than unstressed words.

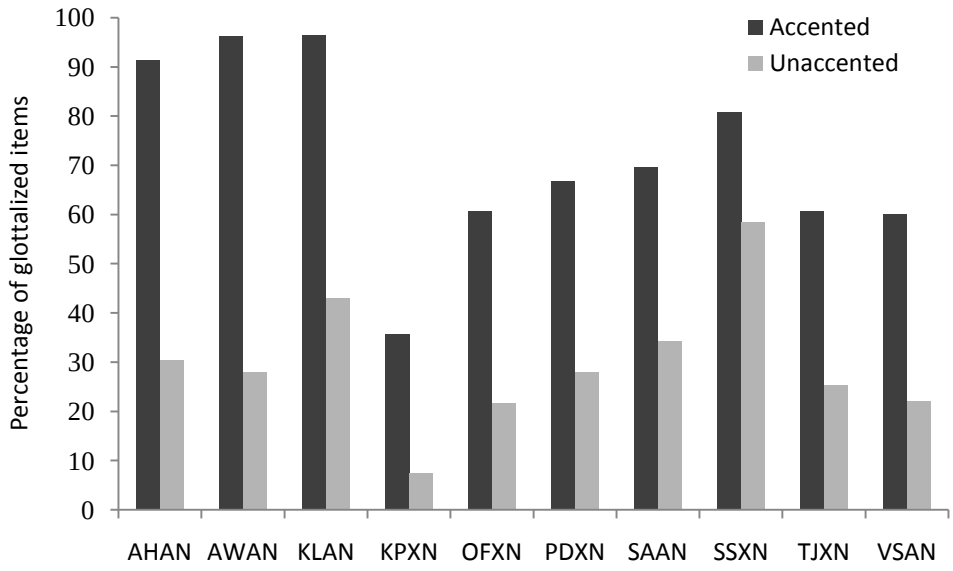

Figure 12. Comparison of the glottalization rate of accented and unaccented words for the ten speakers.

Table 6. The results of statistical analysis concerning the difference between accented and unaccented words. The data demanded Fisher's exact test (FET) to be used in the case of three speakers due to scarcity of data.

Speaker	DF	*n*	χ^2	*p*
AHAN	-	92	FET	< 0.0001
AWAN	-	112	FET	< 0.0001
KLAN	-	100	FET	< 0.0001
KPXN	1	121	11.9	0.0006
OFXN	1	111	13.0	0.0003
PDXN	1	112	12.3	0.0005
SAAN	1	135	11.3	0.0008
SSXN	1	122	3.5	0.06
TJXN	1	120	11.6	0.0007
VSAN	1	114	11.2	0.0008

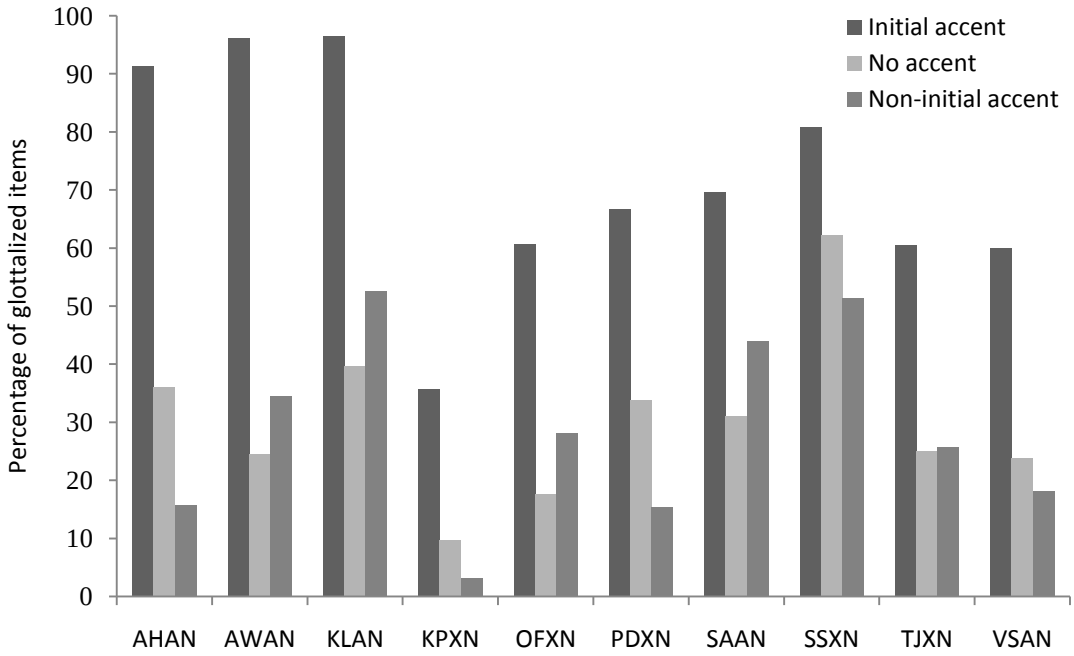

Figure 13. Glottalization rates for the ten speakers. Words divided according to presence (Initial accent) or absence (No accent) of pitch accent on the initial syllable, or its presence later in the word (Non-initial accent).

The relative frequency of glottalization in all the three accent-related categories is presented in Figure 13. In the corpus, the 'no accent' category was the most numerous (n = 590), while the remaining two were represented almost equally (n = 280 for 'initial accent', and n = 269 for 'non-initial accent'). The tendencies of individual speakers concerning the glottalization rate of the two 'unaccented' subcategories go in opposite directions. Judging simply from the graph, five speakers glottalized more in the 'no accent' group, and five did the opposite, although for TJXN, the difference is very small. Not very surprisingly then, the difference between the two groups, for data pooled from all speakers, was not significant [χ^2 (1, n = 859) = 0.06, p = 0.8] and likewise, no significant results were obtained for the speakers individually.

The distribution of the glottalization types in the two original accent categories; that is 'accented' and 'unaccented' for data pooled from all the speakers can be seen in Figure 14 (overleaf). Although the canonical form is more common than the creaky realisation in the accented syllables, the results of statistical analysis showed the relationship between the type of glottalization and vowel prominence to be only marginally significant [χ^2(1, n = 445) = 3.5, p = 0.06].

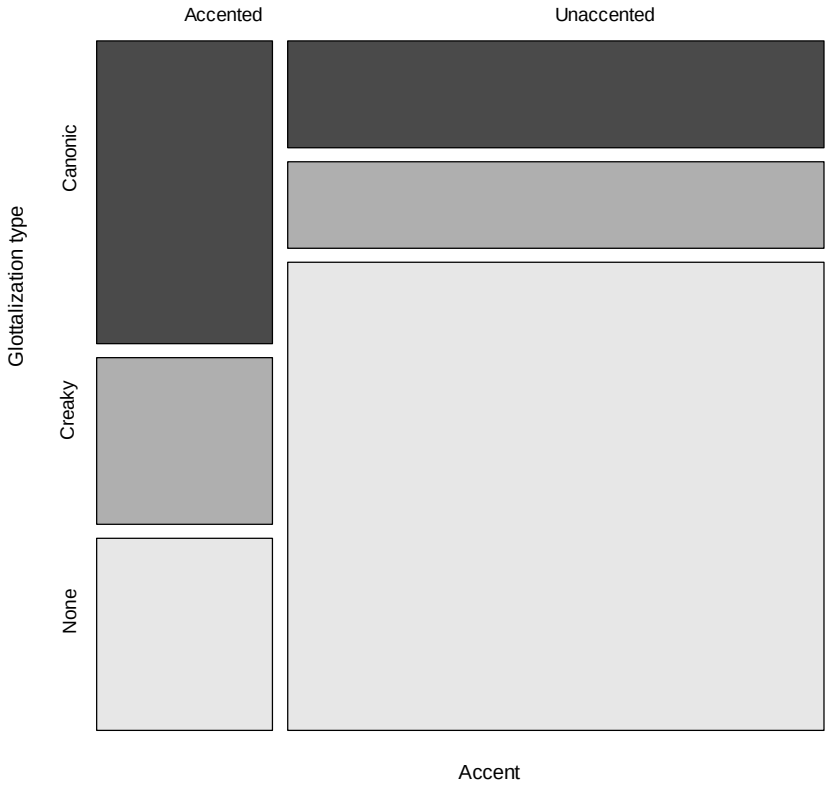

Figure 14. A mosaic plot showing the distribution of glottalization types in relation to word accent.

5. Discussion

The phenomenon of glottalization lived up to its name and proved to be highly variable both in terms of the amount and type of glottalization in the corpus used for the present study. The results pertaining to the rate of glottalization under different conditions will be discussed first, before proceeding to what can be said about the distribution of the different realizations of the glottal stop.

The majority of speakers fell between 33 and 50% overall rate of glottalization, which corresponds roughly with the results for American English in the study undertaken by Dilley et al. (1996, p. 432), where the five professional speakers reached similar scores. Although it is based on a small sample of speakers, narrowing the expected range of glottalization may help to establish some common trends. In the group of speakers analyzed here, the glottalization rate was substantially lower for one of the speakers and higher for two. Analyzing a larger set of below- and above-average speakers might lead to uncovering some common characteristics in their speech that cause or contribute to lowered or heightened glottalization rate.

Word class was presented as one of the factors contributing to the occurrence of glottal stops, but the conclusion cannot be drawn without caution. Significant results were found for the difference in glottalization rate between content and function words, but only with the help of the powerful group of proper names. When these were treated separately from content words, the difference between the two original categories was statistically less convincing. In this way, we may ask what makes proper names different. Starting from the perceptual point of view, glottalization highlights the word, makes it more distinct. It conceivably may be part of a strategy employed by the speakers when uttering an uncommon or contextually important word, i.e. an emphatic function. It was proposed, but with the current sample could not be proven that frequency or familiarity of a word could influence its liability to glottalization. Confirming this possibility would involve a much larger sample and a very careful analysis to ascertain whether, for example, the information structure of a text (new vs. old), or frequency of a given word in language corpora can help to predict or describe the distribution of glottalization in a text, and whether this would apply to all content words. It is however more likely that the semantic and frequency-related factors are weaker and much more difficult to pinpoint securely than those related to prosody (for more arguments on the relative

importance of the factors see below). As a side note, a situation similar to this one, with speakers uttering so many unfamiliar proper names, will probably not frequently happen in spontaneous speech, and is imaginably specific only to certain kinds of written (read) texts.

Prosody has already been shown as one of the main contributors to glottalization. This knowledge motivated the expulsion of words following a pause or breath from the analysis, so that the data would not be contaminated, as the chance of glottalization is close to 100%. In this position, glottalization may well be influenced by mechanical constraints of the vocal tract, although soft beginning is not impossible and is even the norm in some languages that do not allow for glottal stops in initial position (Flack, 2009). As Dilley et al. argued (p. 438), one of the reasons for taking other possibilities into consideration is the fact that a high rate of glottalization can also be observed in phrase-initial position where no pause precedes. The position in the prosodic structure is thus a very likely explanation for the distribution of glottalization and it certainly could be extended on the present dataset. The present study, however, was concerned only with the less conspicuous aspect of prosody, namely pitch accent. The results suggested that the presence of pitch accent heightened the likelihood of a word being glottalized, regardless of the position in phrase (although it may be hypothesised quite safely that pitch accent in connection with phrase-initial position will be a stronger influence than with phrase-medial). Apart from that, there clearly is a correlation with the word class affiliation, as, due to the nature of the English language, many function words receive no stress and hence have lesser chance of being glottalized.

Attempts to make the analysis finer by dividing unaccented words according to whether accent appeared later in the word or not could not replicate the results by Dilley et al. (1996), who found the words with accent appearing later in the word to be glottalized more often than unstressed words. In the present study, no statistically significant difference was observed. Furthermore, when we look at the cross-section of the two studied factors, we may observe that not surprisingly, unstressed words are mostly function words and words with later accent are mostly content words. The difficulty of this sample is that there are not many tokens that would go against this trend (e.g. there are only five unstressed content words). Based on the available data, it is nevertheless apparent that within content words, the items with later stress pattern with those unstressed - and the same applies for function words. This also hints at the relatively smaller role played by semantics, compared to the impact that the absence of accent on the initial syllable has on glottalization.

Based on the results detailed in the previous section, it may be inferred that accented content words and unaccented function words respectively will constitute the most and the least favourable context for glottalization. Yet, approximately 30% of cases in each group did not conform to this prediction. To have the picture complete, it might be fruitful to focus on the already mentioned factor of position in prosodic structure which might account for at least some of the observed anomalies, especially what concerns the glottalized unaccented function words.

As for the three glottalization types, one of them, breathy glottalization was found to be rather rare and as such is not widely discussed in literature. In most speakers, its occurrence was sporadic, counting in units. In one speaker, however, it formed 8% of the glottal stop production. Concerning the two remaining types, in six cases, the ratio of canonical and creaky glottal stops was in favour of canonical glottal stop, in two cases it was balanced and two speakers used the creaky glottal stop more. The voice setting of speaker PDXN, who used the creaky variant five times more often than the canonical one, was prominently creaky which would correspond to the suggestions found in literature that the preference for certain glottalization types might lie in this direction, i.e. a speaker's habitual vocal setting.

Correlation of the type of glottal stop and various factors was found by Rodgers (1999), although his classification was different from the present one. In the present study, only weak correlation was found between accented words and the occurrence of canonical glottal stop. It is however questionable whether this co-occurrence can be explained in terms of causality from this point of view. It is more likely that the type of glottal stop will be determined by the immediate phonetic context, and, as in case of PDXN, by speaker idiosyncrasies.

6. Conclusions

The present study mapped vowel-initial glottalization in British English. It examined read speech of five male and five female speakers and its results were based on an analysis of 1139 words. As was expected, the sample varied from speaker to speaker in the rate and proportion of different types of glottalization. One of the limitations of this paper lies in the fact that finer analysis was often rendered impossible by insufficient size of the sample. Nevertheless, some general tendencies and trends were observed and could be described with some confidence.

The overall rate of glottalization found for the current sample was between 33 and 50% for all but three speakers. Of the two main studied factors, word class and accent, the latter proved to exert more influence. As for word class, the results suggested that in English, unlike in German (see Rodgers, 1999), content and function words do not differ dramatically. On the other hand, proper names showed a higher rate of glottalization, although based on this sample it could not be inferred what exactly caused them to differ. Frequency, familiarity and perhaps other factors may play some role.

The semantic aspect, however, seemed to be overridden by prosodic factors. The presence of pitch accent yielded significantly higher rates of glottalization for all speakers. Counter to the results reported by Dilley et al. (1996), there was no observable difference between words with accent on the first syllable and those with accent later in the word. The latter category, which was mostly composed of content words, had glottalization rates similar to those of unaccented words. This pointed to the greater significance of prosody for the occurrence of glottalization. It can be expected that position in prosodic structure will prove to be an even stronger factor.

The three glottalization types behaved truly unsystematically with respect to the two above-mentioned factors, apart from a correlation of the canonical glottal stop with accented words. It is probable that the type of glottalization is governed by phonetic context or speaker habits rather than word-class or accent.

References

Boersma, P., & Weenink, D. (2012). Praat: doing phonetics by computer [Version 5.3.05]. Retrieved February 20, 2012, from http://www.praat.org/.

Campbell, N. (2000). Databases of emotional speech. *Proceedings of the ISCA Workshop on Speech and Emotion: A Conceptual Framework for Research*, (34-38). Belfast.

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

Cruttenden, A. (2008). *Gimson's Pronunciation of English* (7th ed.). London: Hodder Education.

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

Ding, H., Jokisch, O., & Hoffmann, R. (2004). Glottalization in inventory construction: A cross-language study. *ISCSLP*, (37-40). Hong Kong.

Ding, H., Jokisch, O., & Hoffmann, R. (2006). The effect of glottalization on voice preference. *Proceedings 3rd International Conference on Speech Prosody, 2*, (851-854). Dresden.

Docherty, G., Foulkes, P. (1999). Sociophonetic variation in 'glottals' in Newcastle English. *Proceedings of the 14th International Congress of Phonetic Sciences*, (1037-1040), University of California, Berkeley, 1999.

Esling, J. H., & Harris, J. G. (2003). An expanded taxonomy of states of the glottis. *Proceedings of the 15th International Congress of Phonetic Sciences*, (1049-1052). Barcelona.

Fischer-Jørgensen, E. (1989). Phonetic analysis of the stød in Standard Danish. *Phonetica , 46* (1), 1-59.

Flack, K. (2009). Constraints on onsets and codas of words and phrases. *Phonology , 26* (2), 269-302.

Fougeron, C. (2001). Articulatory properties of initial segments in several prosodic constituents in French. *Journal of Phonetics , 29* (2), 109-135.

Gerratt, B. R., & Kreiman, J. (2001). Toward a taxonomy of nonmodal phonation. *Journal of Phonetics , 29* (4), 365-381.

Gobl, C. (2003). The voice source in speech communication. (Unpublished doctoral dissertation). Stockholm: Kungliga Tekniska Högskolan.

Hanson, H. M., Stevens, K. N., Kuo, H.-K. J., Chen, M. Y., & Slifka, J. (2001). Towards models of phonation. *Journal of Phonetics , 29* (4), 451-480.

Henton, C. G., & Bladon, R. A. (1987). Creak as a Sociophonetic Marker in Language. In I.L. Hyman, & C. N. Li (Eds.), *Speech and Mind: Studies in Honor of Victoria Fromkin* (pp. 3-29). London: Routledge.

Henton, C., Ladefoged, P., & Maddieson, I. (1992). Stops in the World's Languages. *Phonetica , 49* (2), 65-101.

Hillenbrand, J. M., & Houde, R. A. (1996). The role of f0 and amplitude in the perception of intervocalic glottal stops. *Journal of Speech and Hearing Research , 39*, 1182-1190.

Huffman, M.K. (2005). Segmental and prosodic effects on coda glottalization. *Journal of Phonetics*, 33(3), 335–362.

Hůrková, J. (1995). *Česká výslovnostní norma*. Praha: Scientia.

Ito, M. (2005). The contribution of voice quality to the expression of politeness: an experimental study. (Unpublished doctoral dissertation). Edinburgh: University of Edinburgh.

Jones, D. (2003). *English Pronouncing Dictionary.* (P. Roach, J. Hartman, & J. Setter, Eds.) Cambridge: Cambridge University Press.

Jongenburger, W., Heuven, V.J.J.P. van. (1991). The distribution of (word-initial) glottal stop in Dutch. In A. van Kemenade & F. Drijkoningen (Eds.). *Linguistics in the Netherlands* 101 – 110. Amsterdam: John Benjamins.

Kent, R.D. & Read, Ch. (1992). *The acoustic analysis of speech.* San Diego: Singular.

Klatt, D. H., & Klatt, L. C. (1990). Analysis, synthesis, and perception of voice quality variations among female and male talkers. *Journal of the Acoustical Society of America , 87*, 820-857.

Kohler, K. J., Peters, B., & Wesener, T. (2001). Interruption glottalization in German spontaneous speech. *Proceedings of the ISCA Workshop Disfluency in Spontaneous Speech*, (45-48). Edinburgh.

Kohler, K. (2000). Linguistic and paralinguistic functions of non-modal voice in connected speech. *Proceedings 5th Seminar on Speech Production: Models and Data*, (89-92). Kloster Seon.

Ladefoged, P. (1971). *Preliminaries to linguistic phonetics*. Chicago: University of Chicago Press.

Ladefoged, P., & Maddieson, I. (1996). *The Sounds of the World's Langauges.* Oxford: Blackwell.

Machač, P., & Skarnitzl, R. (2009). *Principles of Phonetic Segmentation.* Praha: Epocha.

Malécot, A. (1975). The Glottal Stop in French. *Phonetica , 31* (1), 51-63.

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

Pavelková, I. (2001). K tzv. rázu v češtině. *Jazykovědné aktuality , 38* (4), 78-83.

Pennington, M. (2005). The Phonetics and Phonology of Glottal Manner Features (Unpublished doctoral dissertation). Bloomington, Indiana: Indiana University.

Pierrehumbert, J., & Talkin, D. (1992). Lenition of /h/ and glottal stop. In G. Docherty & D.R. Ladd (Eds.), *Papers in laboratory phonology II* (90-117). Cambridge: Cambridge University Press.

Pompino-Marschall, B., & Żygis, M. (2010). Glottal marking of vowel-initial words in German. *ZAS Papers in Linguistics*, 52, 1-17.

R Development Core Team (2012). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Available from: http://www.R-project.org/.

Redi, L., & Shattuck-Hufnagel, S. (2001). Variation in the realization of glottalization in normal speakers. *Journal of Phonetics , 29* (4), 407-429.

Reetz, H. *UPSID Interface.* Frankfurt University. Retrieved from: http://web.phonetik.uni-frankfurt.de/upsid_find.html

Roberts, J. (2006). As old becomes new: Glottalization in Vermont. *American Speech*, 81(3), 227-249.

Rodgers, J. (1999). Three influences on glottalization in read and spontaneous German speech. *Arbeitsberichte des Instituts für Phonetik und digitale Sprachverarbeitung der Universität Kiel , 34*, 173-280.

Shriberg, E. (1999). Phonetic Consequences of Speech Disfluency. *Proceedings of International Congress of Phonetic Sciences*, (stránky 619-622). San Francisco.

Skarnitzl, R. (2004): Acoustic properties of the glottal stop before the Czech conjunction "a". In: R. Vích (Ed.), *13th Czech-German Workshop - Speech Processing*, Prague, 73-77.

Skarnitzl, R. (2010). Prague Phonetic Corpus: status report. *Phonetica Pragensia , 12* (1), 65-67.

Slifka, J. (2000). Respiratory constraints on speech production at prosodic boundaries. (Unpublished doctoral dissertation). Cambridge, MA: Massatchusets Institute of Technology.

Volín, J. (2012). Jak se v Čechách rázuje. *Naše řeč , 95* (1), 51-54.

Volín, J. (2003). The preposition "of" and glottal stops in Czech English. *Prague Conference on Linguistics and Literary Studies Proceedings*, (stránky 10-19). Prague.

Wells, J. C. (2004). *Longman Pronunciation Dictionary.* London: Pearson.

Żygis, M. (2010). Typology of consonantal insertions. *ZAS Papers in Linguistics* , 111-140.