SPEAKER SPECIFIC STRATEGIES OF VOICING, DEVOICING AND GLOTTALISATION IN GERMAN STOPS

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ABSTRACT

This paper reports the results from an instrumental investigation into speaker specific strategies of stop voicing, devoicing and glottalisation in German. Laryngograph recordings were taken from eight German speakers producing /p, t, k/ and /b, d, g/ preceded by vowels, nasals or /l/ and followed by nasals or /l/. Four of the subjects produced glottalised stops in some phonetic environments, that is, the stop closure was achieved through a constriction of the glottis, and these subjects also showed spontaneous voicing in some of the fortis stops. The other four subjects showed opposing tendencies, that is, they did not produce any glottalized stops and showed passive devoicing in some of the lenis stops. The observed differences may be associated with speaker-specific strategies of velum control and subsequent effects on aerodynamic conditions in stop production.

Keywords: German, stops, voicing, glottalisation, Laryngograph

1. INTRODUCTION

It is well established that stops in German can be voiced, voiceless or voiceless aspirated depending on the phonetic environment, the position within the syllable, and the prosodic structure. In voiced environments, the lenis stops /b, d, g/ can be fully voiced, although devoicing during part of the stop closure is not uncommon [1, 6]. The fortis stops /p, t, k/ are voiceless with varying degrees of aspiration when they are in the onset position of a stressed syllable and followed by a vowel. Glottalised stops can occur in place of nasally released stops when they are followed by a nasal and preceded by a vowel, a nasal or /l/ [5]. Stop glottalisation is believed to be motivated through an increase in articulatory ease, as control of the velum in nasally released stops is argued to be limited. Through employment of a glottalised stop, a speaker can minimise velic raising and lowering whilst signalling a stop closure through a glottal constriction gesture [6]. The present study explores to what extent stop glottalisation is associated with speaker specific tendencies of stop voicing and how these observations relate to the explanations for stop glottalisation proposed in previous research.

2. METHOD

2.1. Subjects and materials

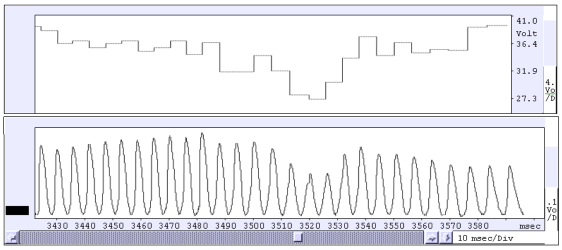
The subjects were four male and four female German speakers who were living in the town of Wolfsburg, Lower Saxony, and with one exception had been brought up in this region. The subjects did not display any noticeable differences in their local accents, which may be described as Standard North German. Three sets of materials were used for data collection. The first set included the stops /p, t, k/ preceded by nasals and followed by nasals or /l/ (15 sequences). The second set, consisting of 6 sequences, contained /p, t, k/ preceded by vowels or /l/ and followed by /l/. The third set, which consisted of 4 sequences, included the lenis stops /b, d, g/ preceded by a vowel and followed by syllabic /l/, as well as /d/ preceded by a nasal and followed by syllabic /l̩/. The sequences were embedded in sentences of uniform length and structure such as, for example, ‘ich denke er zahlt nur drei’ (‘I think he pays only three) containing the sequence /ltn/ in *zahlt nur* [ˈtsaːlt nuːɐ̯]. The utterances were elicited through a ‘word game’ technique involving simple arithmetic tasks. Each subject produced each utterance 10 times, and recordings were taken with a portable Laryngograph (Laryngograph Ltd.) which was connected to a Hewlett Packard Nx5000 laptop computer. The Laryngograph signal (Lx), which reflects changes in vocal fold contact during phonation, was digitised for further processing in the SoundScope 16.1/3 software package.

2.2. Procedure

2.2.1. Correcting the drifting baseline

In order to achieve a steady baseline in the Lx signal, the following method was used: Two neighbouring signal minima were identified and the extent of vertical drift between the two minima was measured. The section between these minima was then re-written whilst each point of the section was vertically shifted in the opposite direction of the drift by increasing fractions of the amount of the drift, thereby compensating for the drift and levelling out the minima. (see lower panel in fig.1).

Figure 1: CQ plot and Lx signal of sequence /mpl/ in *camp lieber* [ˈkɛmp̬ liːbɐ] ('camp rather'), illustrating spontaneous voicing of /p/.



2.2.2. *Correcting the contact quotient (CQ)*

In order to quantify changes in vocal fold contact and to distinguish different types of stop, a contact quotient (CQ) was calculated in the following way: The section between two signal maxima was defined as cycle duration. The value difference between a maximum and the following minimum was defined as signal amplitude. The CQ was calculated by measuring the time span between a signal maximum and the point at which the Lx trace had fallen to 25 per cent of signal amplitude. This amount was divided by glottal cycle duration and multiplied by 100 to represent the CQ, which was plotted over the Lx signal (see fig.1).

2.2.3. *Data extraction*

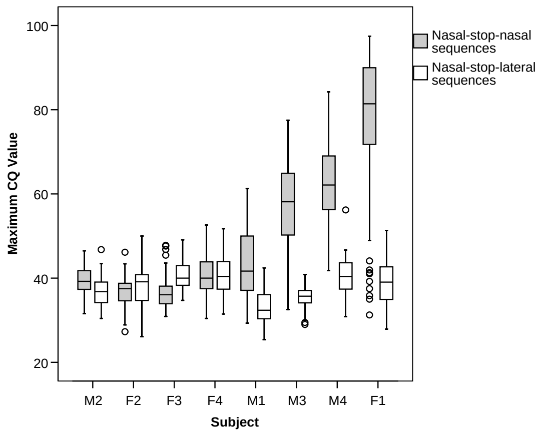
For the purpose of graphic representation, the minimum and maximum CQ values were extracted from each token in the following ways:

1. When the Lx trace showed devoicing through glottal opening, the minimum CQ value in the voiceless portion was selected, as well as the highest value among the three cycles preceding and the three cycles following this portion. Stops produced with glottal opening were typically represented by a very low minimum CQ and a moderately high maximum CQ.
2. When the CQ trace showed increased vocal fold contact (glottalisation) in the region of the stop, the highest point in the CQ trace was selected as well as the lowest value among the three cycles before and after this point. These types of stop typically displayed a raised maximum CQ and a moderate or raised minimum CQ.
3. In stops which were fully voiced without any clear tendencies of increased or decreased vocal fold contact, a spectrogram was used to locate the approximate centre of the stop as a reference point. Minimum and maximum values were selected from a section which included the reference point and the three preceding and following cycles. These types of stop showed moderately high minimum and maximum CQ values which were relatively close to each other.

3. RESULTS

Figure 2 shows the box plot for the maximum CQ values in the nasal-stop-nasal sequences (N=90), and the nasal-stop-lateral sequences (N=60) for all eight subjects. It is apparent that four of the subjects (M1, M3, M4 and F1) produced the nasal-stop-nasal sequences with increased maximum vocal fold contact, that is, they used glottalised variants, while the remaining four subjects (M2, F1, F3, F4) did not produce glottalised stops. In the nasal-stop-lateral sequences none of the subjects employed glottalisation. This result is in agreement with previous studies showing that glottalisation of stops occurs primarily before nasals and only rarely before /l/ [5, 6].

Figure 2: Box plot for maximum CQ values in nasal-stop-nasal sequences (N=90) and nasal-stop-lateral sequences (N=60) for all eight subjects. Stop glottalisation is apparent in nasal-stop-nasal sequences produced by M1, M3, M4, F1.



The two 'groups' of speakers however appeared to differ in other respects as well. Visual examination of the Lx signals suggested that the subjects who did not employ glottalised stops, produced fully devoiced stops throughout, while the subjects who glottalised stops also produced a considerable proportion of fully or partially voiced stops in the same sample.

To test whether the apparent division into two 'groups' was limited to stops followed by nasals, the second set of data were analysed containing /p, t, k/ preceded by vowels or /l/ and followed by /l/. Minimum and maximum CQ values were displayed in scatter plots with the x-axis representing the minimum CQ value and the y-axis the maximum CQ value for each token.

In accordance with the data extraction process outlined above, marker location is related to the voicing parameter as follows:

1. A marker position near the left edge of the plot represents a stop produced with glottal opening.
2. A marker position near the diagonal guide line indicates continuous voicing.
3. A raised marker position suggests glottalisation.

Figure 3 shows the scatter plots for the subjects who glottalised stops in the above mentioned data set (M1, M3, M4 and F1). As expected, glottalisation did not occur in these samples, and it is also apparent from the markers near the diagonal line that all four speakers produced a proportion of the stops voiced or partially voiced.

Figure 3: Scatter plots for /p, t, k/ preceded by vowels or /l/ and followed by /l/ (N=60) produced by subjects who glottalised stops (M1, M3, M4, F1 from left to right).

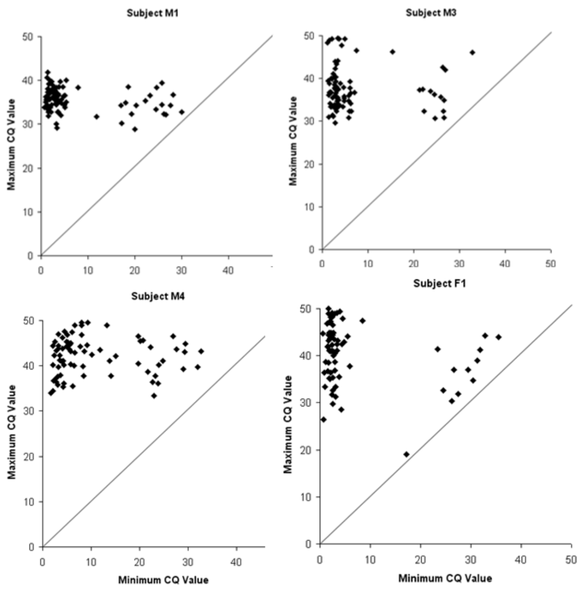


Figure 4 represents the same tokens produced by the subjects who did not glottalise stops (M2, F2, F3, F4). The markers clustered near the left edge of the plot illustrate that, in contrast to the preceding group, all tokens were produced fully devoiced. The third data set, which consisted of 4 sentences, included the lenis stops /b, d, g/ preceded by a vowel and followed by syllabic /l/, as well as /d/ preceded by a nasal and followed by a syllabic /l/.

Figure 4: Scatter plots for /p, t, k/ preceded by vowels or /l/ and followed by /l/ (N=60) produced by subjects who did not glottalise stops (M2, F2, F3, F4 from left to right).

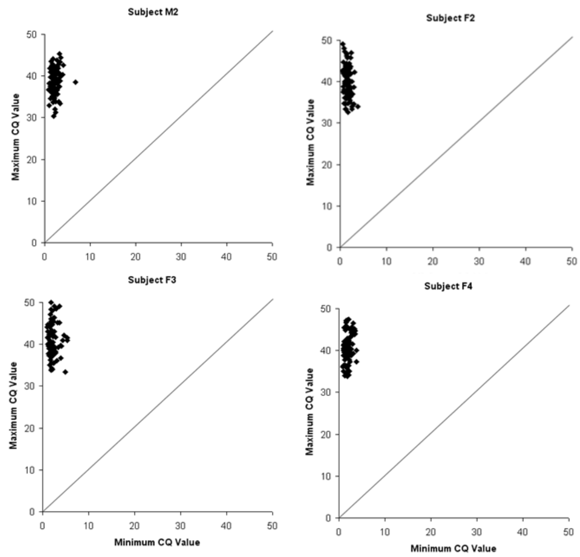


Figure 5 shows the scatter plots for the subjects who glottalised stops, with the markers primarily located near the diagonal line, demonstrating that these subjects produced the stops voiced or partially voiced. In contrast, the scatter plots for the subjects who did not glottalise stops (fig. 6) show a small proportion of markers near the left edge, demonstrating that these stops were produced partially or fully devoiced.

Figure 5: Scatter plots for /b, d, g/ preceded by vowels and followed by syllabic /l/ (N=30) as well as /d/ preceded by a nasal and followed by syllabic /l/ (N=10) produced by subjects who glottalised stops (M1, M3, M4, F1 from left to right).

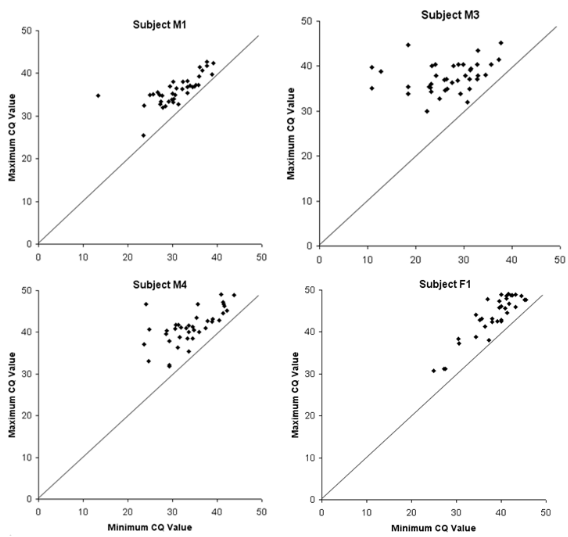
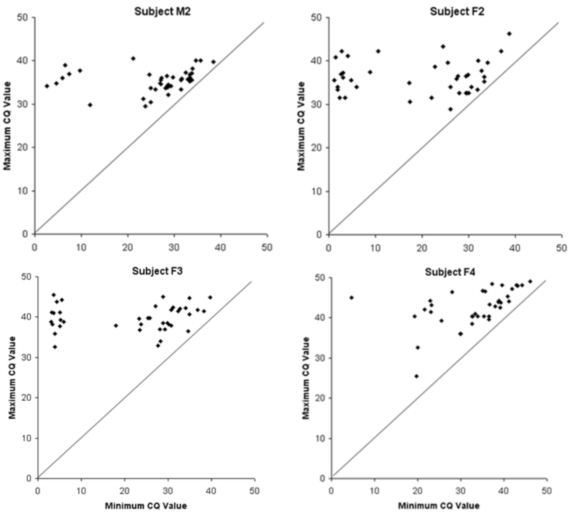


Figure 6: Scatter plots for /b, d, g/ preceded by vowels and followed by syllabic /l/ (N=30) as well as /d/ preceded by a nasal and followed by syllabic /l/ (N=10) produced by subjects who did not glottalise stops (M2, F2,F3, F4) from left to right).



4. DISCUSSION

The results suggest that the speaker-specific use of stop glottalisation is associated with a tendency for stop voicing, while speakers who do not employ glottalised stops show a propensity for stop devoicing. This pattern may be associated with individual differences in velic control during stop production. Speakers have been found to employ different strategies for velum control, which may result in overall differences in velum height [2, 7]. Instrumental investigations also suggest that velum height is lower in stops when the release is nasal rather than oral [3, 4, 8]. If a speaker employs an articulatory strategy which allows for a comparatively low velum position, voicing should be facilitated as nasal leakage could easily occur, reducing the build up of intra oral air pressure during stop closure. At the same time, through the low velum position, the production of nasally released stops could be impeded, necessitating the employment of glottalised stops. A connection between stop glottalisation before nasals and a low velum position in stop-nasal sequences has been demonstrated for American English [9]. A strategy of velum control which results in overall greater velum height would facilitate the build-up of intra-oral air pressure and hence the devoicing of stops, and may also facilitate the production of nasally released stops. Further research however would be needed to establish if such differences in velum height among speakers and the proposed consequences on nasal releases and voicing can be confirmed.

5. REFERENCES

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