SOME IMPLICATIONS FOR GESTURAL UNDERSPECIFICATION AS A RESULT OF THE ANALYSIS OF GERMAN /t/ ASSIMILATION

Anja Geumann and Bernd Kröger
Institute of Phonetics, Cologne, Germany

ABSTRACT

As can be shown for English data, the assimilation of the alveolar stop can result from an increased gestural overlap of the following oral closure gesture. Our experiment with German synthetic speech showed similar results. Further, it suggests that it is neccessary to complete the gestural specification of the glottal state. A voiced stop should be represented not only by an oral gesture, but by a glottal one as well.

1. INTRODUCTION

In German as well as in English, reduction or assimilation of word final alveolar stops in the case of a following labial or velar stop can be found. These phenomena have been described as speechrate, -style dependent. In a gestural approach [1], [2], they can be explained by increasing gestural overlap of the following oral closure gesture.

It is not yet clear what types of gestures are explicitly given for the glottal state, e.g. opening, critical closing. At first approximation, a total underspecification of voicing is found to be underlying, i.e. the default is an critical closed glottis (phonation), even in the case of an oral closure (a stop) [3], [4].

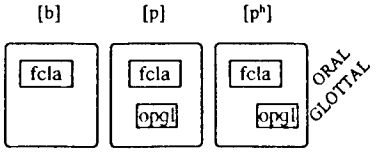

Figure 1. Gestural representation of voicing contrasts. (To be revised). Vertical length of the boxes represents gestural duration.

The sound thus results from the activity of gestures in a certain time interval and in a particular temporal relation, e.g. between labial closure gesture and glottal opening.

In our gestural model, the /b/ vs. /p/ distinction in German is represented as the leftmost vs. the rightmost gestural configuration in Figure 1.

Our goal is to model the assimilation in the sequences /t#p/ and /t#b/, where it is that an intermediate morpheme or word boundary is found. As proposed in segmental descriptions, e.g. [5], /t/ should be assimilated into the place of the following labial stop, as in [tʰb] > [p̪] and [tʰpʰ] > [pʰ].

2. EXPERIMENT

In our experiment, synthetic speech stimuli were used containing /t#p/ and /t#b/ stop sequences (as a minimal pair contrast) in three-word phrases: <Er geht packen> ('He is going to pack'), <Er geht backen> ('He is going to bake'). The stimuli were synthesized using a gestural based articulatory speech synthesizer at the Cologne Phonetics Institute [6]. In this model, a self-oscillating glottis model is implemented [7]. In both contexts the gestural overlap of the following labial gesture was increased in 7 equidistant steps from 0% to 100%, as could be seen in Figure 2. The glottal gestures are temporal associated to the respective oral gesture. Thus, the overlap of the glottal gestures increases in the same way.

In a second part of the experiment, in addition to the overlap of the oral gestures, the first glottal opening gesture (associated with the apical gesture) decreases in temporal and spatial extension (see Figure 3). Thereby, the offset of the glottal gesture is synchronized with the onset of the labial gesture. The stimuli were randomized and presented to 32 native listeners, without experience in synthetic speech. In a forced choice situation they were asked to decide whether or not there was /t/, and if there was /p/ or /b/.

In this way, listener judgements should show if place assimilation was perceived at all, and, whether there was - as proposed - a perceptual salient /b/ vs. /p/ discrimination even at full overlap.

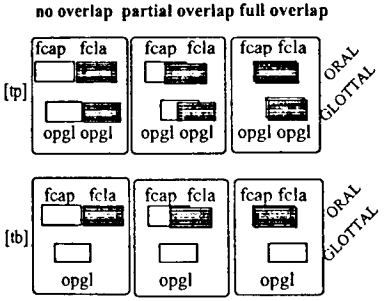

Figure 2. Increasing gestural overlap in the /tp/ (upper row) and /tb/ (lower row) sequence, with unreduced first glottal opening gesture. Gestures: fcap - apical full closure; fcla - labial full closure; opgl - glottal opening.

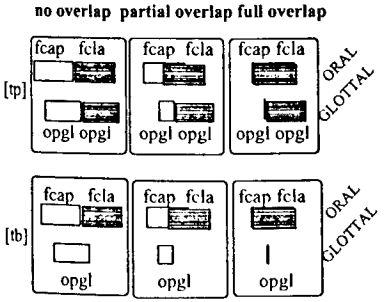

Figure 3. Increasing gestural overlap and decreasing glottal opening gesture, with a total reduced opgl at full overlap. In fact, at full overlap, the (first) opgl has disappeared.

Firstly, it was found in the experiment that gestural overlap is perceived as /t/ assimilation or reduction. The results for /t/ assimilation were significant in all four contexts (/tb/, /tp/; with/without glottal reduction). In Figure 4 a general survey is given. (It should be noted, that the data in Figure 4 differ from those of Byrd [2]. This might result from the somewhat differing gestural specification. Within the model used by Byrd, after 67% of gestural inherent time, the full closure was reached; in our configuration, this occured after 45% of inherent time. This might have led to assimilation judgements at a lower percentage of overlap in our experiment.)

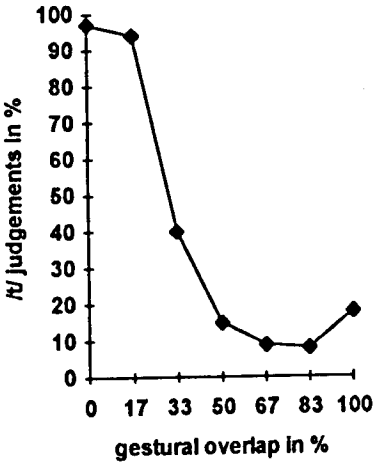

Figure 4. /t/ judgements for all four contexts. (non-/t/ = assimilation)

Secondly, the results suggest that there has to be a reduction (in space & time) of the glottal opening gesture in the /t#b/ context. In the /t#p/ sequence, there was no significant difference in whether the first glottal opening gesture was reduced or not. As seen in Figure 5, listeners tend, with increasing gestural overlap, to perceive a /p/ in the /t#b/ sequence if the preceding glottal opening

gesture is not reduced. The acoustic data in Table 1 confirm this.

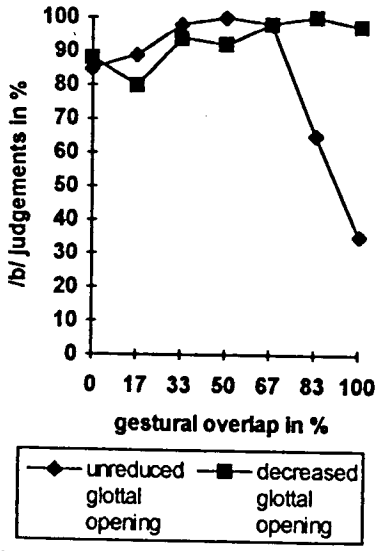

Figure 5. /b/ judgements for the /tb/ sequence. (non-/b/ = /p/ judgement)

Table 1. Duration of aspiration of the /tb/ sequence, without reduction of opgl.

Overlap in %	Aspiration in ms
0	-
17	-
33	-
50	5
67	5
83	20
100	25

3. CONCLUSION

There seems to be a kind of asymmetry in the behavior of glottal gestures for /tp/ vs. /tb/. For /tp/, we assume that it is unnecessary to reduce the first glottal opening gesture as in Figure 2. In the /tb/ sequence, on the other hand, it was shown necessary to decrease the glottal opening gesture, as in Figure 3.

The temporal association of the glottal gesture with the onset of the following oral gesture, certainly, is a first attempt. If one does not want to give up the autonomy of the oral and glottal articulators, the problem should be solved within the glottal articulator. It seems reasonable to secure the voicing of the labial stop by an additional glottal gesture.

For this reason, we suggest introducing **a glottal critical closing gesture** associated with the '/b/' oral closing gesture in German, which dominates (blends with) a preceding glottal opening gesture. This means one must have contrastive gestural specification for the glottal state of stops.

Further, if the glottal critical closing gesture (ncgl), as in Figure 6, has only a short duration, it allows at least partial devoicing, as might often be the case in German [p̥], see [5].

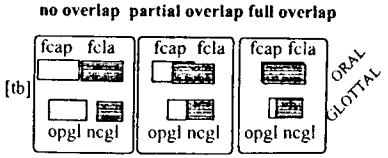

Figure 6. Contrastive gestural specification of the glottis.

The introduction of this additional gesture also seems to be appropriate from a phonological markedness point of view. This means, in a gestural model, a voiced stop should be specified with no fewer gestures than a (unmarked) voiceless stop.

ACKNOWLEDGEMENTS

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