Tongue, jaw and laryngeal behavior in the production of posttonic /d/ and /t/ in German

Susanne Fuchs[1,2], Christine Mooshammer[1], Pascal Perrier[3] & Phil Hoole[4]
1: Research Centre for General Linguistics (ZAS) Berlin, 2: Queen Margaret University College Edinburgh,
3: Institut de la Communication Parlée Grenoble, 4: Institut of Phonetics and Speech Communication Munich
fuchs@zas.gwz-berlin.de

BACKGROUND

For Standard German it is generally agreed that the voicing distinction in final position is neutralized, i.e. voiced obstruents become devoiced in word final position. Acoustical measurements showed that under certain contextual and pragmatic conditions this neutralisation process was incomplete.
From a productional point of view voiced and voiceless stops in initial and medial position not only differ in laryngeal behavior, but also in supralaryngeal characteristics (e.g. Löfqvist 1980, Löfqvist & Gracco 1994). It is unclear, whether supralaryngeal differences could also be found for the final position.

Aims of this study:

1. investigation whether relicts of the articulatory differences are also found in final position
2. comparison between different linguistic materials, i.e. nonsense words with more natural words

DATA ACQUISITION

Simultaneous recordings by means of:
- EMMA (AG 100 Carstens Medizintechnik)
- EPG (Reading EPG3)
- Acoustic recordings on DAT

3 German speaking subjects:
CG, JD (males), SF (female)

Nonsense words (N) and real words (R):

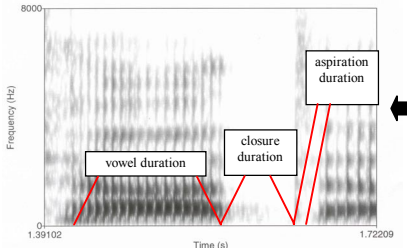
/CVC/ /rVC/
C = /d,t/
V = stressed /a/

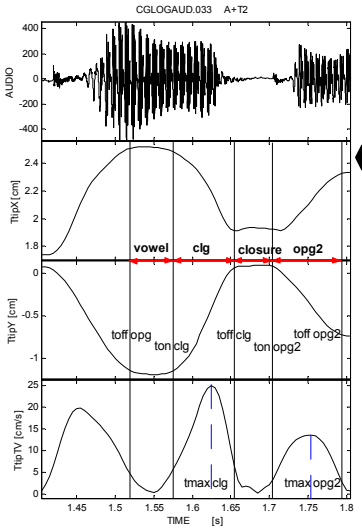
- embedded in the following sentences:

Ich habe geCaCe, nicht geCVC erwähnt. (I said geCVCe, not geCVC.)	Ich habe mein Rad erkannt.(I recognised my bike.)
	Ich habe Rat erbeten. (I asked for advice.)

Repetitions: 10 for nonsense words, 7 for real words

Significance tests ANOVA with Post hoc Scheffé





opg = opening gesture
clg = closing gesture
opg2 = opening gesture 2

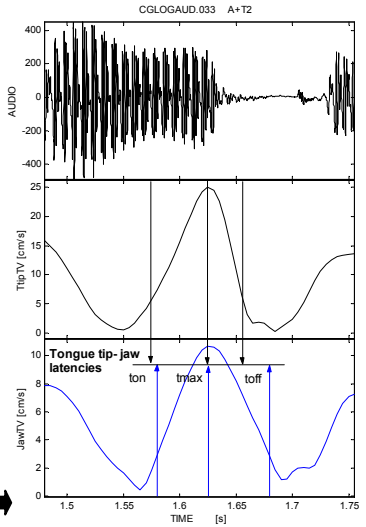
- same landmarks served for jaw sensor
- note, tongue tip sensor could be influenced by jaw movements

RESULTS

Subject	CG		JD		SF	
N = Nonsense words	d/t	d/t	d/t	d/t	d/t	d/t
R = Real words	N	R	N	R	N	R
Acoustics						
vowel duration	+	=	+	=	+	=
closure duration	=	=	=	=	=	-
aspiration duration	-	-	=	-	=	=
EPG contact during closure						
max ant	=	=	=	=	=	-
max post	-	=	=	=	=	=
max lat	-	=	=	=	=	-
max centr	=	=	=	=	+	=
max cog	+	=	=	=	+	=
tongue tip						
tang. vel. peak values:						
tmax clg	=	=	+	+	+	=
tmax opg2	+	=	+	=	=	=
mov. amplitude:						
vowel	=	#	=	#	=	#
clg	+	=	+	=	=	=
closure	=	=	=	-	=	=
opg2	+	=	+	=	=	=
position: x at ton clg	=	=	-	=	=	+
y at ton clg	-	=	-	=	=	=
x at tmax clg	=	=	=	=	=	=
y at tmax clg	-	-	-	-	=	=
x at toff clg	=	=	=	=	=	=
y at toff clg	=	=	-	=	=	=
duration: vowel	=	#	-	#	-	#
clg	=	=	=	-	-	=
closure	-	=	=	=	=	-
jaw						
tang. vel. peak values:						
clg	=	=	+	=	=	=
opg 2	=	=	=	=	=	=
mov. amplitude:						
vowel	=	#	=	#	=	#
clg	=	=	=	=	=	=
closure	=	=	=	=	=	=
opg 2	=	=	=	-	=	=
position: x at ton clg	=	=	=	=	-	=
y at ton clg	-	=	-	=	=	=
x at tmax clg	-	-	=	=	=	=
y at tmax clg	-	=	-	=	-	=
x at toff clg	=	=	=	=	=	=
y at toff clg	-	=	-	+	=	=
duration: vowel	=	#	=	#	=	#
clg	=	-	=	=	=	=
closure	=	=	=	=	=	=
tongue-jaw phase						
ton	-	=	+	-	-	=
tmax	-	=	=	=	=	=
toff	-	=	=	=	-	=

Summary of significant differences
(ANOVA with Post hoc Scheffé)
- /d/ lower, smaller, shorter or more retracted compared to /t/
= no significant difference
\+ /d/ higher, longer, more forward compared to /t/
\# analysis not possible
red fields = p<0.001
blue fields = p<0.01
grey fields = p<0.05

ant = % of contact in the 4 most anterior rows
post = % of c. in the 4 most posterior rows
lat = % of c. in the 2 left & 2 right columns
cog = centre of gravity index (weighting in the front – back direction; a large cog = more back)
centr = centrality index (weighting in the peripher – centralised direction; a large centr = more centralised)



SUMMARY

From a productional point of view the neutralisation process is not complete.
For nonsense words the following differences were found (at least for 2 out of 3 subjects):
1. duration of the preceding vowel (! note, that the consonant preceding the vowel differs also in terms of aspiration, so that this result has to be taken with caution)
2. tang. velocity of tongue tip is higher for /d/ than /t/ in the second opening gesture
3. movement amplitude is larger for /d/ in the closing gesture and the second opening gesture
4. tongue tip and jaw show a lower vertical position for /d/ than for /t/ at the beginning of the closing gesture and at the velocity peak; the jaw also shows a lower position for reaching the target in the closing gesture
5. tongue-jaw phase is shorter for /d/ than for /t/ in the beginning of the closing gesture and at the target

In real word material differences become less and more speaker specific:
1. aspiration duration is shorter for /d/ than /t/
2. tongue tip exhibits a lower position for /d/ than /t/ at the time of the peak velocity in the closing gesture

CONCLUSIONS

From the production point of view, neutralisation is not complete. The results vary with the linguistic material, i.e. differences decrease and are less consistent with more natural words, which could be caused by hyperarticulatory effects for the nonsense material. Results from natural words show a higher interindividual variation too.
The higher vertical position for tongue tip at the velocity peak in /t/ could be interpreted as a strategy to reduce oral cavity volumn and increase intraoral pressure.
Tongue-jaw latencies seems to play a role at the target position, i.e. tongue tip and jaw move relatively synchronously for /d/, but not for /t/. For /t/ the jaw target is achieved later than the tongue tip target. Up to now we did not decompose the tongue tip signal, i.e. our measurements are based on the composite movements of jaw and tongue tip which could also influence the more subtle differences in the real word corpus and will be investigated further.

Acknowlegement
Work supported by German Research Council (DFG) grant GWZ 4/5-2(A1).

References

Löfqvist, A. (1980): Interarticulator programming in stop production. Journal of Phonetics 8, 475-490.
Löfqvist, A. & Gracco, V.L. (1994): Tongue body kinematics in velar stop production: Influences of consonant voicing and vowel context. Phonetica 51, 52-67.