Homophonous phonotactic and morphonotactic consonant clusters in word-final position

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Abstract

Morphonotactic clusters are defined as combinations of phonemes across morpheme boundaries. As they are cognitively processed faster and acquired earlier than phonotactic clusters, it is hypothesised that in speech production, morphonotactic clusters are more robust and highlighted than phonotactic clusters.

The aim of this study was to compare homophonous phonotactic and morphonotactic consonant clusters. Homophonous target words produced in semi-spontaneous speech of 16 Standard Austrian German speakers were analysed.

Word-final morphonotactic and phonotactic consonant clusters were analysed with respect to relative duration and intensity of both the clusters and the cluster-final /t/. Additionally, closure duration of the final-/t/ and the intensity of the burst were measured.

Contrary to the assumption, a global comparison of the clusters revealed no difference in the relative duration of morphonotactic clusters as compared to the phonotactic counterparts. Likewise, concerning the word-final /t/ no differences between phonotactic and morphonotactic clusters occurred. Unexpectedly, gender- and age-specific differences arose, independent of the phonotactic / morphonotactic distinction of the clusters.

Index Terms: morphonotactics, phonotactics, consonant cluster, Standard Austrian German, homophones

1. Introduction

Phonotactic rules specify allowed sequences of phonemes in a given language, which occur within a single underived morpheme, whereas combinations of phonemes across morpheme boundaries are termed morphonotactic clusters [1]. The focus of this study is on consonant clusters, which could occur both as phonotactic and as morphonotactic clusters.

Studies on first language acquisition showed that morphonotactic clusters are learned earlier [2, 3] or at least not later [4] than phonotactic clusters. Differences in the cognitive representation between phonotactic and morphonotactic clusters were detected in a computational simulation [5]. In perception experiments, adults recognised words faster, if there is a phoneme combination at the word boundary which does not occur within words [6]. In phoneme combinations which could occur within morphemes as well as across morpheme boundaries, the morphonotactic cluster is detected faster in processing experiments [7]. This result could be due to the higher information content of morphonotactic consonant clusters, because they contain morphological information.

In phonetics, systematic studies dealing with this topic are rare. Investigations of consonant clusters in English showed more deletions of word-final coronal stops in monomorphemic words than in inflected verbs [e.g. 8, 9]. However, a study conducted by [10] revealed that phonological context effects have a greater influence on the deletion of word-final /t/ than the morphological information contained in word-final /t/. Likewise, in a study on Dutch, Schuppler et al. [11] observed that the segmental context is an important factor for the realisation of /t/. In particular, /t/ is more susceptible to deletions in consonant clusters than between vowels. Otherwise, if the /t/ is only reduced, not the context, but more general processes, mainly the speed of articulation are the main factors influencing the reduction [12]. Another result of the study of [11] was that there is a direct relation between word frequency and the reduction or deletion of word-final /t/. Equally, word frequency plays a crucial role in the duration of homophones; frequent words are shorter than a homophonous infrequent word. [13]. Furthermore, [14] found out that grammatical category of the word influences word duration such that nouns are longer than verbs [14].

From the results on first language acquisition, psycholinguistic experiments, and computer simulations, we assume that these effects are also reflected in speech production. The results on coronal stop deletions confirm our assumption that, as an extension of the Strong Morphonotactic Hypothesis [15], morphonotactic clusters are more robust and more highlighted in speech production than phonotactic clusters; they are e.g. less susceptible to deletions and reduction processes.

In the present study, homophonous target words containing either phonotactic or morphonotactic consonant clusters were elicited in a semi-spontaneous speech task. Such a task was designed, because a previous study [16] analysing target words embedded in carrier phrases in a post-focal position revealed no distinction between phonotactic and morphonotactic clusters.

2. Material and method

2.1. Subjects and recordings

Semi-structured interviews containing approximately 20 minutes of spontaneous speech and several reading tasks were conducted with 16 speakers of two age groups (20-25 years and 45-55 years), balanced for gender. All subjects were speakers of Standard Austrian German as defined by [17]. Since in several studies [18, 19, 20], the Standard Austrian German variety as spoken in Vienna turned out to be most prestigious, we concentrated on speakers born and raised in Vienna, with at least one parent born and raised in Vienna as well. The subjects were students or university graduates. At least one parent has an academic education or both parents have a qualification for university entrance.

2.2. Material and procedure

Seven different consonant clusters consisting of two, three or four consonants were selected, because for these consonant clusters homophone word-pairs exist, of which the consonant cluster either had a phonotactic or morphonotactic status. 20 monosyllabic German words (nouns and conjugated verbs) were selected as target words. The selected clusters and the corresponding target words are shown in Table 1.

Table 1: *Consonant clusters and target words*

	phonotactic	morphonotactic
[st]	Hast *(hurry)*	hasst *(you hate)*
		hasst *(he/she hates)*
	Mist *(dung, rubbish)*	misst *(you measure)*
		misst *(he/she measures)*
[nt]	Band *(volume, ribbon)*	band *(I/he/she tied)*
[nd̥]	Rind *(cow, beef)*	rinnt *(it flows)*
[ft]	Schaft *(stem)*	schafft *(he/she creates, works)*
[xt]	Macht *(power)*	macht *(he/she makes)*
[nst]	Dienst *(service)*	dienst *(you serve)*
[pst]	Propst *(provost)*	probst *(you rehearse)*
[ŋkst]	Hengst *(stallion)*	hängst *(you hang)*

The target words were elicited in a semi-spontaneous speaking-task. The participant had to read a question and answer it spontaneously by including two given words: the target word and another word, whereby the latter helps to more easily find an answer to the question. In order to prevent an exaggerated word stress on the target word, it was already included in the question. That way, in answering the question, the new information was not given by the target word, but by the second given word or it was invented by the speakers:

Hast, Schlüssel — *Was vergisst dein Nachbar oft in der Hast mitzunehmen?*

(hurry, key — *What is your neighbour often forgetting when he is in a hurry?)*

The recordings of the speakers were segmented, annotated, and transcribed manually. Thereafter, measurements and semi-automatic extraction of the following acoustic parameters were carried out: relative duration and intensity (RMS amplitude) of the words, clusters, individual consonants of the clusters, and phonemes surrounding the clusters. In addition, the final consonant of the clusters was analysed with respect to the duration of the closure, the intensity of the burst or whether affrication of the plosive occurred.

In order to eliminate duration differences of nouns as compared to verbs and the influence of the speaking rate, the relative duration of the clusters and their individual consonants were calculated by determining the duration in proportion to the word length. Likewise, in order to eliminate global differences in intensity, the relative intensity was calculated in relation to the intensity of the vowel preceding the cluster. The measurements of the parameters were analysed statistically with R by using t-tests and analyses of variance, if necessary, followed by Tukey HSD post-hoc tests. For the not normally distributed intensity values, Wilcoxon rank sum tests with continuity correction were used.

3. Results

3.1. Duration and intensity of the clusters

A global comparison of morphonotactic and phonotactic clusters revealed no statistically significant differences, neither with respect to relative duration nor with respect to relative intensity (see Figure 1 and Table 2).

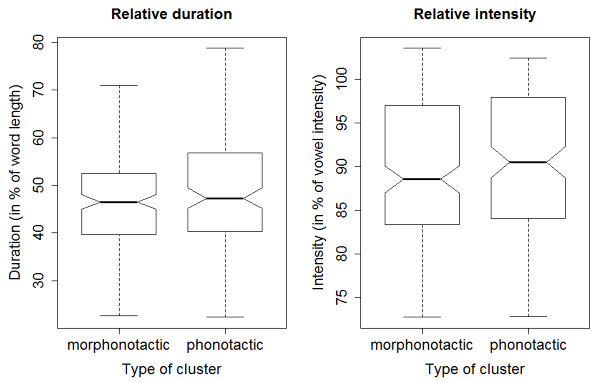

Figure 1: *Relative duration and intensity*

Table 2: *Duration and intensity values of the clusters*

in %	all clusters	morphono-tactic	phono-tactic	p-value
Duration				
mean	46.62	46.00	47.41	0.2175
SD	10.20	9.48	11.04	
Intensity				
mean	86.18	85.85	86.61	0.4098
SD	8.34	8.24	8.47	

The duration values are relative values in % of word length;
The intensity values are relative values in % of the intensity of the vowel preceding the cluster

A two-way ANOVA was calculated revealing no interaction between the phonotactic / morphonotactic distinction and the composition of the cluster with both the relative duration (see Figure 2) and the relative intensity. Furthermore, no significant interaction between type of cluster and the manner of articulation of the phoneme following the cluster was found.

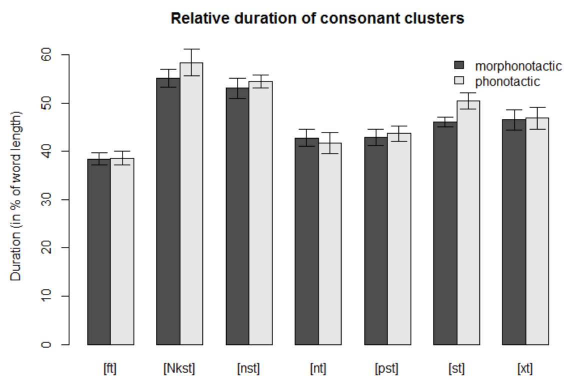

Figure 2: *Detailed analysis of the relative duration of the clusters*

3.2. Word-final /t/

In total, in 69 out of 336 clusters the final-/t/ was deleted acoustically. The percentage of deletions was higher in morphonotactic clusters (25.39 %) than in phonotactic clusters (14.29 %) and differed considerably between the different clusters (see Figure 3).

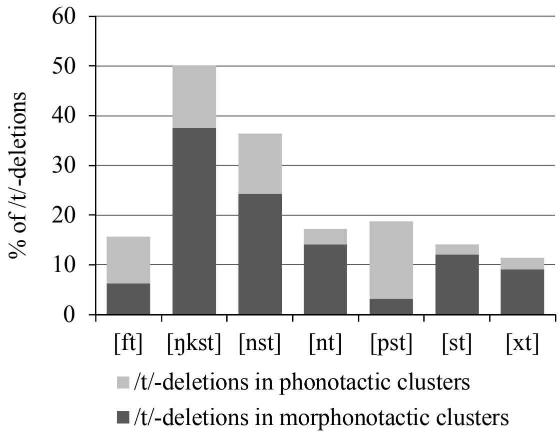

Figure 3: *Word-final /t/-deletions*

The analyses presented in 3.1. were repeated by excluding the clusters in which a word-final /t/ had been deleted. As regards relative duration, no statistically significant differences occurred. However, the results concerning relative intensity revealed a tendency towards a higher relative intensity of phonotactic clusters (W = 7797, $p = 0.085$).

Considering word-final /t/ only, no statistical significant differences in relative duration and intensity occurred between the two types of clusters. Likewise, no statistical significant differences in closure duration of /t/ emerged with respect to phonotactic and morphonotactic clusters.

Singling out the affrication of affricated word-final /t/, again, no statistical significant differences in relative intensity and relative duration emerged in the comparison of the two types of clusters. The same holds for the analysis of the relative duration of the aspiration phase.

Comparing the burst intensity of the final /t/, a t-test revealed a not significant tendency for the phonotactic clusters having a higher relative intensity of the burst of the final /t/ than the morphonotactic clusters ($t(154) = -1.841$, $p = 0.068$). An overview of the results is given in Table 3.

Table 3: *Word-final /t/*

in %	all clusters	morphono-tactic	phono-tactic	p-value
/t/ duration				
mean	19.22	19.60	18.79	0.366
SD	7.40	7.54	7.24	
/t/ intensity				
mean	74.32	73.96	74.72	0.452
SD	8.21	7.71	8.75	
closure duration				
mean	11.32	11.75	10.84	0.181
SD	5.85	6.23	5.40	
burst intensity				
mean	74.01	72.88	75.19	0.068
SD	7.99	7.35	8.50	
affrication intensity				
mean	74.52	75.52	73.28	0.125
SD	8.57	8.61	8.45	
affrication duration				
mean	8.14	7.98	8.34	0.621
SD	3.67	3.86	3.45	
aspiration duration				
mean	6.69	6.72	6.67	0.737
SD	4.11	3.93	4.32	

The duration values are relative values in % of word length;
The intensity values are relative values in % of the intensity of the vowel preceding the cluster

3.3. Age and gender differences

3.3.1. Duration

A multi-way ANOVA revealed a highly significant main effect of gender ($F(1,328) = 14.751$, $p < 0.001$) with a longer relative duration of the clusters in male speakers and a significant interaction between age and gender ($F(2,328) = 8.973$, $p < 0.05$) (see Figure 4). However, no interaction with the type of cluster occurred. Post-hoc tests showed that in the age group of the elder speakers, results on relative duration of all clusters were highly significant ($p < 0.001$), showing lower relative durations for female speakers than for male speakers. Additionally, significant differences occurred between young male speakers and the elder female speakers ($p < 0.05$) and equally between the elder male speakers and the young female speakers ($p < 0.05$).

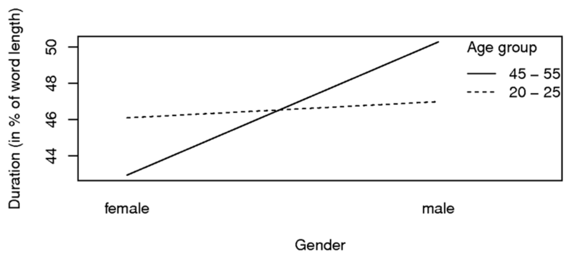

Figure 4: *Age-gender-interaction*

3.3.2. Intensity

The statistical analysis of the relative intensity showed a highly significant difference between the genders (W = 10549, $p < 0.001$) (Figure 5), but no differences between the two age groups and no interaction of gender and age. Again, concerning the phonotactic / morphonotactic distinction, no differences occurred.

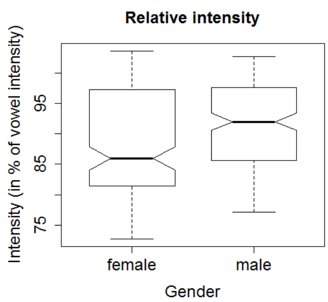

Figure 5: *Gender differences in the relative intensity of the clusters*

3.3.3. *Final /t/-deletion*

Deletion of the final consonants revealed large inter-speaker variability. Some speakers rarely deleted the final consonant, whereas others showed up to 40 % deletions. In Figure 6, the deletion-rates of the speakers are shown.

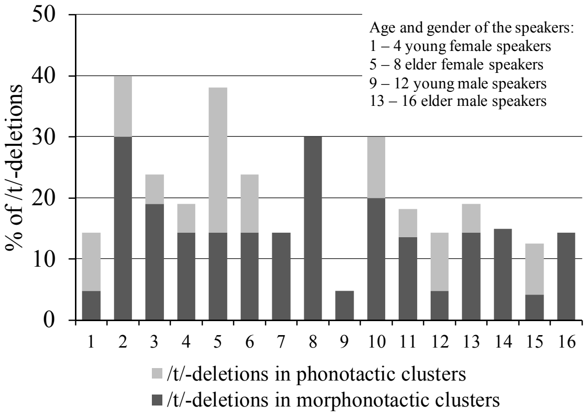

Figure 6: *Inter-speaker variability in final /t/ deletions*

4. Discussion

The aim of the present study was to investigate potential differences in speech production between phonotactic and morphonotactic consonant clusters at word-final position in Standard Austrian German.

A global comparison showed that neither in the relative duration nor in the relative intensity of the clusters a significant difference between the two types of clusters emerged. Likewise, no interaction of the morphonotactic / phonotactic distinction with the composition of the cluster could be observed, which indicates that the results could not be explained by contrary tendencies in the different clusters. Furthermore, no interaction between the phoneme following the clusters and the type of cluster occurred. These results indicate that at least in word-final phonotactic and morphonotactic consonant clusters of homophonous word pairs the expected distinction between the types of clusters in speech production is not existent.

In comparing the realisations of the final consonant of the clusters, it was interesting to see that the final /t/ was more frequently deleted in morphonotactic clusters (25.39 %) than in phonotactic clusters (14.29 %). This contrasts with the findings of Guy [8]. In addition, the frequency of deletions differed considerably between the different clusters, which could be due to the fact that the phonological context has more influence on /t/-deletion than the morphological information content of word-final /t/, as [10, 12] showed. The differences in the proportions of deletions in phonotactic and morphonotactic clusters could possibly also emerge from the influence of the phonological context following the clusters. However, due to the fact that semi-spontaneous speech was investigated, a large inter- and intra-speaker variability in the phoneme following the consonant cluster exists which could mask a possible influence of the following phoneme in the statistical evaluation.

Concerning the sub-segmental analysis of the word-final /t/, no significant differences occurred with respect to the phonotactic / morphonotactic distinction. Only for the burst intensity a tendency for a higher relative intensity of the burst in phonotactic clusters could be observed.

Unexpectedly, gender- and age-specific differences emerged with respect to relative duration and intensity of the clusters. In particular, relative duration of all clusters was shorter in the group of elder females compared to the group of elder male speakers and the relative intensity of the clusters was higher in the male speakers. However, age- and gender-specific differences did not affect the morphonotactic / phonotactic distinction.

To summarize our results, in production, phonotactic and morphonotactic consonant clusters are not distinguished by Standard Austrian German speakers, meaning that the maintenance of durational aspects and intensity is more important than the distinction of higher level grammatical categories. Thus greater ease of processing of morphonotactic than of phonotactic clusters is probably due to the interaction between morphology and phonology, insofar as the former contain more information than the latter, but this is not expressed in the acoustic phonetic signal.

At this point, prosody needs to be introduced into the discussion. In a typology set up by [20, 21], languages are threaded on a gradual scale from a prototypical word language to a prototypical syllable language. As has been shown by [22], Standard Austrian German can be classified as a mixed type, since it also features quantifying aspects in its prosodic organization. Therefore, in the temporal organization of spoken sequences, a significant deviation from the temporal pattern due to, e.g. the phonotactic / morphonotactic distinction of homophones, might severely disturb the overall prosodic structure of the sequence. Our results on final /t/ deletion corroborate this assumption, since the phonological context has more influence on word-final /t/ deletion than the morphonotactic / phonotactic distinction.

On the other hand, a language featuring more word-prosodic aspects, as, e.g. English, the morphonotactic / phonotactic distinction can outweigh the prosodic organization. The results presented by Guy [8] point into this direction.

Consequently, in our future work, we will look more deeply into the interaction of prosody and (mor)phonotactics. In a cross-linguistic perspective, our results could have far-reaching implications for language typology.

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