Phonological categoricality vs. phonetic gradience:
The laryngeal properties of Slovak three-consonant clusters

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In this paper we examine the behavior of word-final monomorphemic /kt/, /gd/, /st/ and /zd/ clusters in Voicing Assimilation (VA) contexts in Slovak in the following test words *kontakt* 'contact', *smaragd* 'emerald', *chvost* 'tail', *drozd* 'blackbird'. The topic is of interest for two reasons. Firstly, because Slovak is a pre-sonorant voicing language, and, secondly, because our earlier findings suggest that word-final singleton /t/–/d/ as well as /s/–/z/ are completely neutralized for their laryngeal specification, i.e. they either assimilate in voicing to the following sound (be it an obstruent, sonorant consonant or vowel) or undergo word-final devoicing. That is to say, VA is categorical in Slovak. Finally, we would like to contribute to research on the laryngeal properties of three-member consonant clusters (see for instance, Strycharczuk 2012, Recasens & Mira 2013, Kulikov submitted)

The question whether an alternation is categorical or gradient has been the focus of phonological debate. According to the generative tradition, whether a variation is categorical or not is fairly straightforward, and if it is, it can be described with categorical values of phonological features, e.g. [±voice]. On the other hand, the question of gradiance is far from settled. A process is thought to be gradient if the phonetic characteristics of the variants (such as acoustic cues) reflect values in between these categories (e.g. partly voiced), or if some but not all acoustic cues are affected by assimilation (partial neutralization), or if a segment systematically shows a different amount of voicing before different classes of sounds: voiced obstruents > sonorant consonants > vowels > voiceless obstruents. Our previous work on singleton obstruents in Slovak showed that all the relevant acoustic correlates of voicing (phonation, consonant duration, duration of the preceding vowel, intensity) are affected by assimilation, suggesting that the process is completely neutralizing and therefore categorical. However, the target sounds were found to be more voiced before voiced obstruents than before sonorants, which suggests that the process is gradient. The analysis of clusters can shed light on whether VA in Slovak is more of a low level coarticulatory process or it is rather categorical.

We conducted an experiment with 6 native speakers of Slovak (4 repetitions for each token) and measured the duration of the clusters, the amount of voicelessness during their closure /constriction interval, the duration of the pre-cluster vowel, the intensity of the cluster consonants, and took account of the type of cluster simplification (if both members of the cluster were preserved or if there was deletion, the presence/lack of burst release, approximant-like realization, etc.) in the following contexts: (i) absolute final; (ii) word-final (wf) followed by a vowel initial word; (iii) wf followed by a sonorant consonant; (iv) wf + voiced obstruent and (v) wf + voiceless obstruent, and as a point of comparison, (vi) intervocalic position within the same word.

(i)	V prvom rade bude topás a **smaragd**.	'Topaz and emerald will be in the first line.'
(ii)	Najznámejšie sú **smaragd a** rubín.	'The most well-known are ruby and emerald.'
(iii)	Achát a **smaragd majú** zelenú farbu.	'Agate and emerald are green'
	Smaragd ligotavý je obľúbený.	'Shiny emerald is beloved.'
(iv)	Mal u seba **smaragd bývalej** kráľovny.	'He had the former queen's emerald with him.'
(v)	Doniesol **smaragd prasknutý** na dvoch miestach.	'He brought the emerald broken at two places.'
(vi)	**Magda** je moja kamarátka z Prešova.	'Magda is my friend from Prešov.'

Our research objectives in this paper are the following: (1) We hypothesize that if VA in Slovak is a low-level coarticulatory process – as long as both members of the cluster are maintained –, the proportion of voicing in the cluster context should be different than in the

singleton context. That is, if assimilation is a consequence of gestural overlap then the absolute duration of the voiced part should be fairly constant. On the other hand, if it is categorical then it is the *proportion* of voicing that should be fairly constant.

(2) We also wanted to test Jansen's (2004) functional model with respect to CCC clusters. According to Jansen, pre-sonorant voicing is only possible in languages with final devoicing because the segment that undergoes pre-sonorant voicing must be targetless for laryngeal specification (Jansen 2004; Strycharczuk 2012). In our previous work on singletons we did find support for this, and also found that Slovak has taken pre-sonorant voicing (PSV) to its "extreme" (i.e. all obstruents undergo it and it applies before all sonorants) as opposed to Dutch (De Schutter & Taeldeman 1986) or Catalan (Jiménez & Lloret 2008) for instance, where only subclasses of obstruents undergo PSV and/or only takes place before subclasses of sonorants. This alternation seems to be fully phonologized in Slovak.

Our preliminary results show the following: 1. similarly to singleton consonants, VA in Slovak is fully neutralizing, i.e. we found no significant difference between any of the acoustic correlates of voicing mentioned above between /kt/, /gd/, /st/ and /zd/ clusters in any context.

2. In intervocalic position both /-gd-/ and /-zd-/ are fully realized and fully voiced, see (1).

3. Clusters (with both members maintained) in all positions are 30–50% longer than singletons.

4. C_2 (the alveolar stop) tends to be deleted in $C_1C_2\#C_3$ sequences, especially when it follows a fricative.

5. In cases of no consonant deletion, when the cluster is long, therefore aerodynamically it is difficult to maintain voicing, phonation typically dies out in C_2, so approximately 60–70% of the cluster is voiced (inducing a voiced percept), (2).

6. In partly voiced tokens the actual vocal fold vibration typically originates from the left, from the preceding vowel. Even in the devoicing environment when the cluster is followed by a /p/-initial word. This supports Jansen's idea that historically PSV is not regressive VA but rather a uncounteracted continuation of passive voicing from the vowel on the left to the target consonant, which is reinterpreted phonologically as 'voiced'.

7. The pre-vowel context has to be treated separately due to the frequent silent intervals and glottalizations separating the CC cluster and the vowel. In this context we found bimodal distribution: either "regular" VA or final devoicing.

The realization of *drozda* (1) and *smaragd majú* (2)
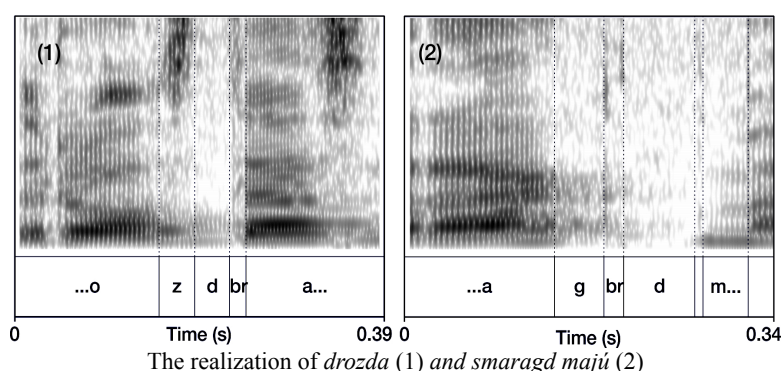
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