

## STOP RELEASE IN POLISH ENGLISH — IMPLICATIONS FOR PROSODIC CONSTITUENCY

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### **Abstract**

Although there is little consensus on the relevance of non-contrastive allophonic processes in L2 speech acquisition, EFL pronunciation textbooks cover the suppression of stop release in coda position. The tendency for held stops in English is in stark opposition to a number of other languages, including Polish, in which plosive release is obligatory. This paper presents phonetic data on the acquisition of English unreleased stops by Polish learners. Results show that in addition to showing a tendency for the target language pattern of unreleased plosives, advanced learners may acquire more native-like VC formant transitions. From the functional perspective, languages with unreleased stops may be expected to have robust formant patterns on the final portion of the preceding vowel, which allow listeners to identify the final consonant when it lacks an audible release burst (see e.g. Wright 2004). From the perspective of syllabic positions, it may be said that ‘coda’ stops are obligatorily released in Polish, yet may be unreleased in English. Thus, the traditional term ‘coda’ is insufficient to describe the prosodic properties of post-vocalic stops in Polish and English. These differences may be captured in the Onset Prominence framework (Schwartz 2013). In languages with unreleased stops, the mechanism of submersion places post-vocalic stops at the bottom of the representational hierarchy where they may be subject to weakening. Submersion produces larger prosodic constituents and thus has phonological consequences beyond ‘coda’ behavior.

**Keywords:** coda stop release, L2 speech, phonetics-phonology

### **1. Introduction**

In the area of second language (L2) phonological acquisition, the status of non-contrastive allophonic processes is not entirely clear. One influential theory, Best’s Perceptual Assimilation Model (PAM; Best 1995, Best & Tyler 2007) is devoted to the

perception of L2 *contrasts* rather than phonemes or allophones, yet success in acquisition is predicted on the basis of sub-phonemic phonetic detail. Flege's Speech Learning Model (SLM; Flege 1995) hypothesizes that L2 phonological acquisition is based on phonetic categories defined at the position-sensitive allophonic level, yet many SLM-inspired studies investigate the implementation of contrasts that are clearly phonological. Similar discrepancies may be found in the closely related area of loanword phonology (for a review, see e.g. Kang 2011), where researchers have made conflicting claims about the relative role of phonetic perception and universal phonological constraints. For example, Hindi and related languages, which contrast /t/ and retroflex /ʈ/, adapt English /t/ as /ʈ/ even though the retroflex stop is absent from the source language. This discrepancy has been attributed to the fact that retroflexion is a contrastive feature in Hindi; its phonological status in the L1 apparently overrides the phonetic properties of the L2 input (Arsenault 2009). In a contrasting example, speakers of French in Quebec and continental Europe show different strategies in their adaptations of English /θ/. In Quebec, speakers substitute /t/ while in Europe they use /s/. The difference is attributed to the fact that /s/ in European French is dental, while it is alveolar in Quebec French. Since the difference between dental and alveolar /s/ is not contrastive, the loanword phenomenon is claimed to be due to purely phonetic considerations. In sum, research into L2 phonology and loanword adaptation has found apparently conflicting evidence with regard to the role of non-contrastive phonetic features. In what follows, we shall offer a theoretical perspective that may help to reconcile this conflict.

While theoretically-oriented studies disagree about the status of allophonic detail in second language speech acquisition, didactically oriented works in applied English linguistics note that certain allophonic processes are crucial for achieving proficiency. Both Cruttenden (2001) and Cook (2000) devote significant attention to features such as the tapping of /t/ and syllabic productions of nasal consonants. The role of phonetic detail is especially evident in the case of voice contrasts in both word-initial and word-final position. Jenkins (2000) represents a somewhat liberal approach to English phonological acquisition espoused in research on English as a Lingua Franca (ELF). She nevertheless emphasizes the importance of voicing-related allophonic processes for the goal of international intelligibility. The effects of final voicing on the preceding vowel are argued to be crucial to enhance contrasts with a high functional load in the lexicon of English. The same is true of aspiration, which, when not acquired successfully can lead to misperception of the voicing specification of initial stops in learner English. At the same time, Jenkins disregards other allophonic processes, such as the realization of /l/ as 'clear' or 'dark', as being secondary and not crucial for intelligibility. Thus, once again it is difficult to gauge the relative importance of non-contrastive phonetic features in L2 acquisition.

One of the more interesting allophonic processes found in English is the suppression of stop release. Stops may, with varying degrees of frequency and stylistic consequences, remain unreleased in forms such as *kit*, *top*, *hot dog*, and of course countless others. As these examples show, unreleased stops may appear before obstruents, as well in absolute final position. The tendency for held stops in English is in stark opposition to a number of other languages, including Polish, in which plosive release is obligatory (Dukiewicz & Sawicka 1995). However, since stop release is generally accepted to be a non-contrastive phonetic feature across languages, its non-

phonological status has diminished the impetus for cross-linguistic studies. Consequently, unreleased stops have been largely neglected in the field of second language phonology.

This paper has two goals. First, phonetic data will be presented on the acquisition of English unreleased stops by Polish learners. Our results show that the suppression of stop release, despite its non-contrastive status, is clearly part of the acquisition process for L1 Polish speakers learning English. The second goal of this study is to explore a hypothesis concerning the representation of prosodic constituents, by which unreleased stops arise from purely phonological parameters. In other words, despite its non-contrastive status, stop release is a phonological phenomenon. The hypothesis is formulated within the Onset Prominence framework (Schwartz 2013). The essence of the proposal is that post-vocalic stops come in two varieties. In languages with unreleased stops they are joined with the preceding vowel into a single constituent by a process of *submersion*. In languages with obligatory release the submersion process is parametrically absent.

The submersion proposal makes additional predictions that go beyond the question of whether a stop is produced with an audible release. Since submerged stops are joined with the preceding vowel into a single constituent structure, VC sequences in languages with unreleased stops should be characterized by a greater degree of phonetic cohesiveness than in languages with obligatory release bursts. This cohesiveness may be measured in the VC formant transitions that are observable on vowels in pre-consonantal position. In our study, we measured these transitions in the speech of Polish learners of English. Our results show that in addition to showing a tendency for the target-language pattern of unreleased plosives, advanced learners acquire more native-like VC formant transitions. From the functional perspective, robust formant patterns may be seen as a perceptual license allowing for listener identification of unreleased stops (see e.g. Wright 2004). The acquisition of native-like VC sequences, with suppressed stop release and robust formant patterns, suggests that learners have acquired an aspect of English prosodic organization.

The rest of this paper will proceed as follows. Section 2 will provide background on the phonological and phonetic considerations that are relevant for the study of coda stop release. Section 3 will describe the experimental methods of our study and present the results. Section 4 will provide discussion of the phonological parameter of submersion and the framework in which it is derived.

## 2. Phonological and phonetic background

In the languages of the world, there are no known cases of a phonological system in which stop release is a contrastive property that may distinguish two phonemes. It is therefore generally assumed that the release of plosive consonants is not phonologically relevant, but rather represents a sub-phonemic phonetic detail. Although this is the mainstream view, some authors have argued that stop release is indeed incorporated into phonological grammars. Evidence for the phonological relevance of stop release may be found in the phonological properties of contour segments such as pre-nasalized stops and affricates; Steriade (1993) shows that only stops and affricates can be split into nasal and

non-nasal portions and hypothesizes that stops must therefore be made of two separate root nodes. Others have noted the systematic nature of cross-linguistic generalizations regarding the release of stops in coda position as evidence of the phonological status of stop release. For example, in languages such as Korean, stop consonants in coda position are always produced without release. By contrast, in Polish plosive release is obligatory. Finally, the suppression of stop release may be optional, as we observe in English.

Cross-language interaction of coda stop release systems was observed by Kang (2003), who showed that the probability of epenthetic vowels following English coda stops in loanwords into Korean (*pad* → /pæ.ti/) is strongly correlated with the probability of stop release in the speech of L1 speakers. Kang noticed three such effects from a study of the TIMIT corpus of English of American English: (1) voiced stops, (2) stops following tense vowels, and (3) coronal stops were more likely to be released. When the source language stops are more likely to be released, the Korean adaptations showed a strong tendency to be characterized by an epenthetic vowel and an additional syllable. By contrast, the adaptations of English words with a tendency for unreleased stops matched with the native Korean pattern of suppressed stop release (*pack* → /pæk̚/). In sum, despite the non-contrastive status of stop release, there is reason to believe that the phenomenon is indeed phonological.

With regard to the area of English pronunciation pedagogy, textbooks devote some attention to the issue of plosive release. Cruttenden (2001) emphasizes the fact that stop release is suppressed in the first consonant of CC sequences, both at word boundaries and within words. Further, he notes that the failure to suppress stop release may contribute to a tendency for native English speakers to hear an additional [h] sound, or a CV sequence with a schwa in the case of voiced consonant sequences. In studies of cross-language intelligibility, such epenthesis processes have been found to have profound effects on the probability of correct identification of an utterance. This presumably stems from the fact that epenthetic segments affect the prosodic structure to be perceived. Thus, the acquisition of stop release suppression may be suggested to be an instrumental aspect of prosodic learning in L2 English. In the context of L1 Polish speakers learning English, previous studies by Bergier (2010) and Rojczyk et al. (2013) have investigated the production of unreleased stops.

The phonetic forces underlying stop release may be thought in terms of Lindblom's (1990) H&H theory of speech production. In Lindblom's model speech production is realized on a continuum of speech styles ranging from hyper-articulated (careful and emphatic) to hypo-articulated (casual) speech. Lindblom suggests that speakers adjust their utterances along this continuum in order to achieve the goal of 'sufficient discriminability' while economizing effort. In other words, speakers control their speech output according to whether they feel that their utterance will be understood. If a less effortful realization of a given word or phrase may be recovered on the basis of any number of linguistic or non-linguistic factors, speakers will minimize the effort in producing it. If listeners may identify the place of articulation of an unreleased stop, the impetus to spend the effort to produce stop release is lessened.

The recoverability of unreleased stops lies in the acoustic properties that may be observed on the later portion of the vowel in VC sequences (e.g. Wright 2004). The formation of stop closure produces distinct formant patterns on the preceding vowel as a function of the place of articulation, allowing listeners to identify where the constriction

is made even in the absence of audible release. Consequently, cross-linguistic differences with regard to the obligatory or optional nature of stop release may be hypothesized to be related to cross-linguistic differences in the robustness of VC formant patterns. In languages that suppress stop release this acoustic robustness reflects a significant degree of phonetic cohesion between the V and the C. In languages like Polish with obligatory release, the acoustic transition is predicted to be less robust than in languages with optional or obligatory suppression of release, reflecting a smaller degree of articulatory coordination in the production of the VC sequence. Differences in phonetic coordination in turn suggest a difference in the prosodic affiliation of the C in VC sequences. In other words, an unreleased stop may be thought of as ‘attached’ to the preceding vowel, while obligatory stop release suggests that this is not the case. We will return to the implications of stop release in Section 4. Now, we shall turn to a description of the experimental study.

### 3. Acoustic study of stop release in the speech of Polish learners of English

On the basis of the phonetic and phonological considerations discussed earlier, we hypothesize that Polish learners at different levels of proficiency will differ with regard to the release of post-vocalic stop consonants, and these differences will also be reflected in the formant transitions on the preceding vowel. In what follows, we present an acoustic study investigating this hypothesis.

#### 3.1 Experimental method

Fourteen Polish students of English took part in the experiment. Seven of the students were in the first year of English studies at the Institute of English at the University of Silesia (Uniwersytet Śląski). The other seven were in advanced years of study (3<sup>rd</sup> year and higher) at the Faculty of English at Adam Mickiewicz University (UAM) in Poznań. This division formed an independent variable (First Year/Advanced) for our analysis. The advanced students had completed rigorous training in English pronunciation over their first two years at university. The first year group had completed only 6 weeks of this training focusing almost entirely on the English vowel system.

The experiment elicited a series of 36 VC#C sequences in English in which the first consonant were stops. The data set was balanced, containing equal number of tokens with regard to C1 and C2 place of articulation (labial, coronal, dorsal), C1 voicing, and vowel quality (/i:/, /ɪ/, /æ/). Unrelated tokens used for another experiment were also included in the data elicitation task. A total of 504 tokens was analyzed (36 tokens \* 14 speakers).

The tokens were presented to the participants on Power Point slides on a computer monitor housed inside a soundproof recording booth at the two universities. Both recording studios are equipped with high quality microphones and USB audio interfaces that allow for recording directly onto the hard drive of a computer. The recordings were made at sampling rate of 44 kHz, with 24 bit quantization.

Acoustic analysis was performed by hand with the help of the Praat program (Boersma & Weenink 2011) and focused on both the release of the post-vocalic stop consonant and the VC formant transitions. With regard to stop release, tokens were tagged as either Yes or No, on the basis of whether there was both a visual spike in the waveform as well as an audible burst. With regard to the vowels in the VC sequences, the following acoustic measurements were made.

- Overall vowel duration (including pre-vocalic /r/ and /l/) in milliseconds
- Duration of VC transition in milliseconds, from the end of the steady-portion of the vowel to the onset of stop closure.

From these measurements, one additional measure of VC formant transitions was calculated, %VC, defined as the transition duration divided by the vowel duration multiplied by 100. An illustration of the VC transition measurement is given in Figure 1, which is taken from a token of the phrase *drag down*. In the selected portion of the figure one may observe the formant excursion from the vowel target positions for the /æ/.

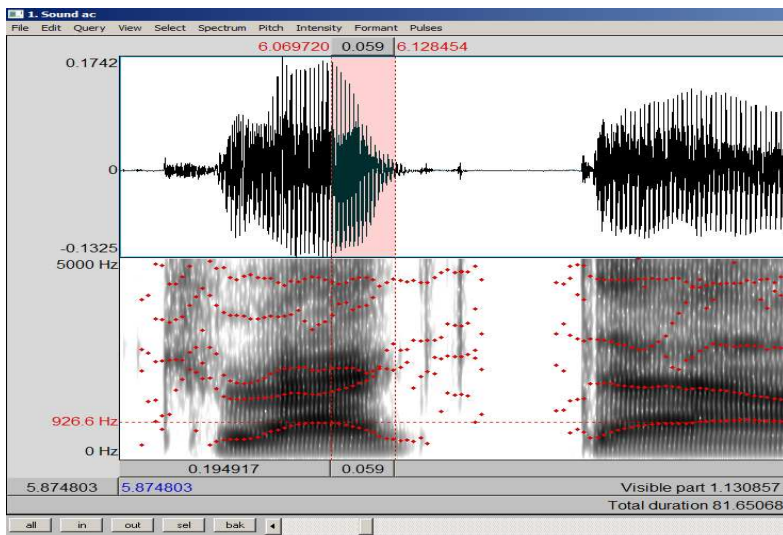
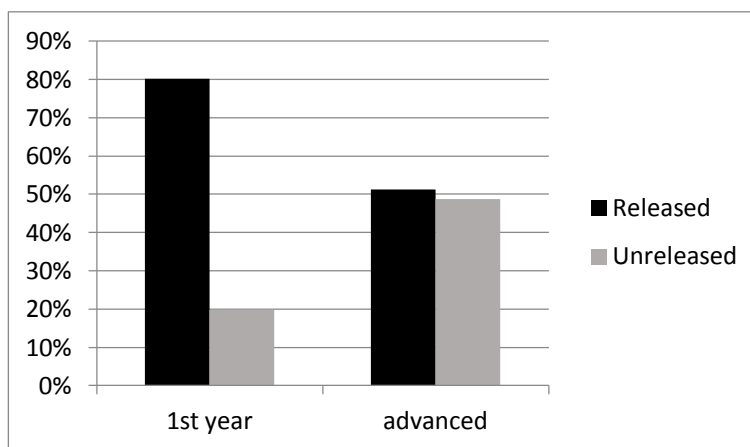


Figure 1: Example of VC transition measurement in *drag (down)*

### 3.2 Results

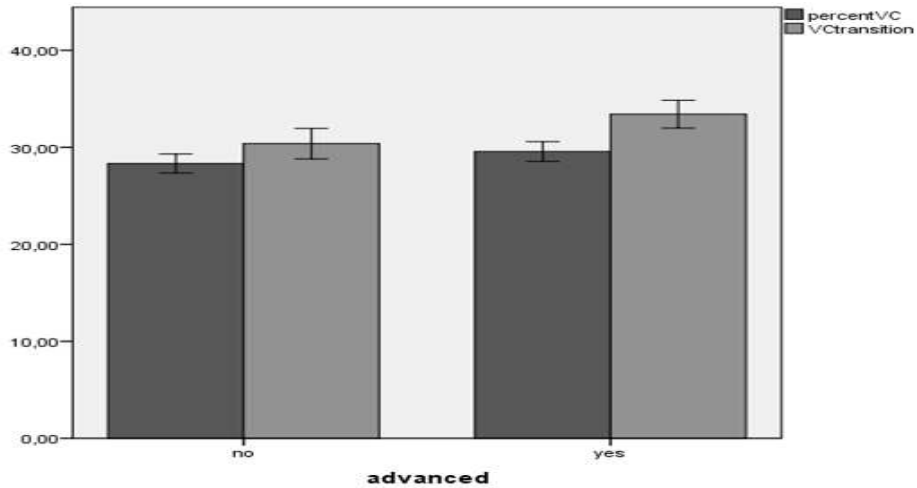
The first set of results is given in Figure 2, which shows the rate of stop release as a function of learner group. The first year group produced release bursts in 80% of the overall tokens, while the higher years' group produced unreleased stops in 51% of the tokens.



**Figure 2:** Rates of stop release (%) as function of learner group

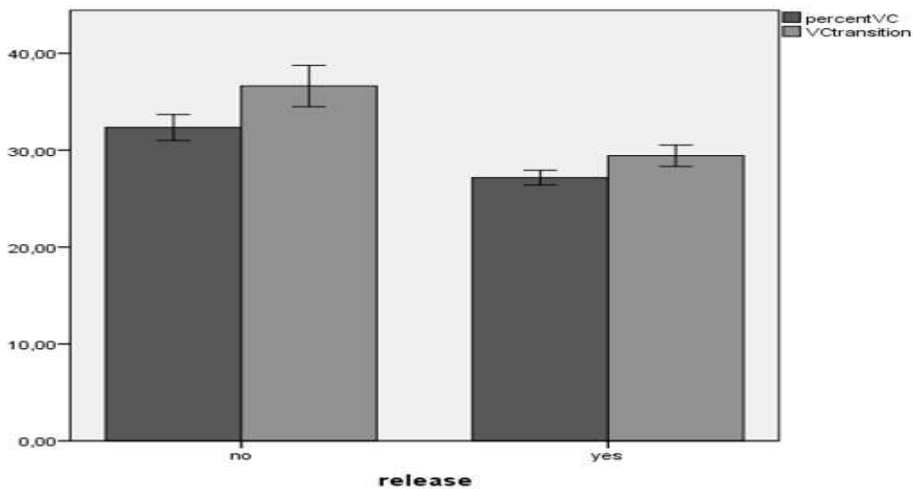
To investigate how various independent variables affected the likelihood of stop release production, a binary logistic regression analysis was carried out, with release as the dependent variable. Learner group (advanced), homorganic place in C#C sequences, and %VC (higher), were all significant predictors of unreleased stops ( $p < .001$  for each predictor). Higher VC transition duration also showed a tendency for unreleased stops, but this effect only approached significance ( $p = .08$ ). The effects of vowel quality (tense vs. lax) and C1 voicing were not significant. The results of the regression analysis suggest that the suppression of stop release is indeed an important aspect of L2 phonological acquisition for the advanced group, and that there was indeed a link between the formant transitions on the preceding vowel and the probability of stop release.

Figure 3 shows the means of the VC transition parameters as a function of learner group. The Advanced group showed slightly higher measures for both parameters. A one way ANOVA was carried out on the mean values. In the case of %VC, the difference (29.6% vs. 28.3%) approached significance,  $F(1, 502) = 2.96$ ;  $p = .08$ . For VC transition duration the difference (33.4 ms vs. 30.3 ms) was significant,  $F(1, 502) = 7.87$ ;  $p = .005$ . These results suggest a modest effect of learner group on the acoustic robustness of VC transitions in C#C sequences.



**Figure 3:** Mean VC transition measures as a function of learner group. Error bars show 95% confidence intervals

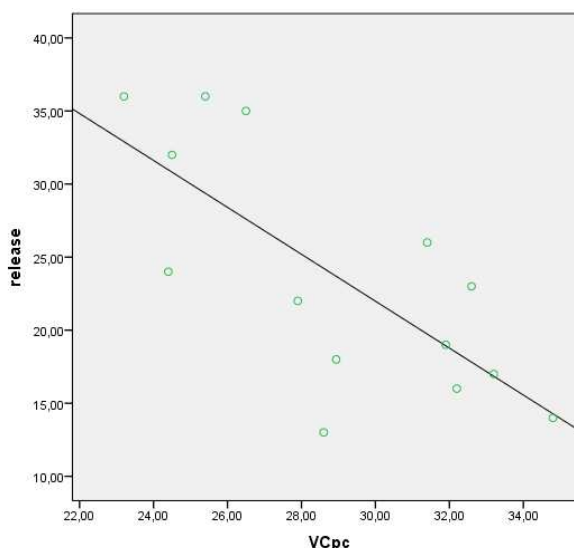
Figure 4 presents a summary of the results for the VC transitions parameters as a function of stop release across both groups. The unreleased stops had higher mean measures for both of the VC transition parameters (36.6 vs. 29.4 ms for VC duration; 32.3% vs. 27.2% for %VC). A one way ANOVA revealed that the differences in both parameters were significant ( $F(1, 502) = 51.3$ ;  $p < .001$  for %VC;  $F(1, 502) = 42.6$ ;  $p < .001$  for VC duration). These results suggest a robust link between the realization of the VC formant transitions and the probability of release.



**Figure 4:** Mean VC transition measures as a function of stop release. Error bars show 95% confidence intervals.



In the case of the individual results, we may also observe a link between the robustness of VC formant transitions and the likelihood of unreleased stop production. This is shown in Figure 5, in which we see an inverse correlation between the mean %VC measures for each individual speaker and the number of stop release bursts ( $r=-.737$ ,  $p=.003$ ).



**Figure 5:** Individual results for stop release and %VC parameters

### 3.3 Discussion

The implications of our experimental results may be summed up as follows. In the speech of Polish learners of English, advanced learners show signs of acquiring target-like suppression of coda stop release in VC#C sequences. The production of stop releases is accompanied to some extent by changes in the quality of the preceding vowel as measured in the formant transitions in the approach to the stop closures. This link is seen in the significant differences in both vowel parameters as a function of stop release. That is, the unreleased tokens produced by the learners in both groups showed more robust VC transitions according to the measured parameters. The VC parameters as a function of learner group showed a more modest effect, but also indicated that acquisition of unreleased stops entails the acquisition of the formant patterns on the basis of which listeners may identify the stop consonant in coda position. The individual results also supported the tested hypothesis.

Taken together, these results suggest cross-language phonological interaction in the production of coda stop releases, providing general support for the notion that non-contrastive phonetic properties may play a significant role in L2 phonological acquisition. The results also suggest that the traditional phonological perspective,

according to which a post-vocalic consonant in word-final position, regardless of language, occupies a ‘coda’ position, is in need of revision. In other words, it appears as though there are two types of ‘coda’ stops: those in languages like English and Korean with unreleased stops and greater phonetic cohesion with the preceding vowel, and the those in languages like Polish with obligatory release bursts and less robust VC transitions. Since this difference appears to be systematic, we feel it should be representable in an adequate phonological framework. In the next section, we shall offer a phonological description of this difference in the Onset Prominence framework (Schwartz 2013).

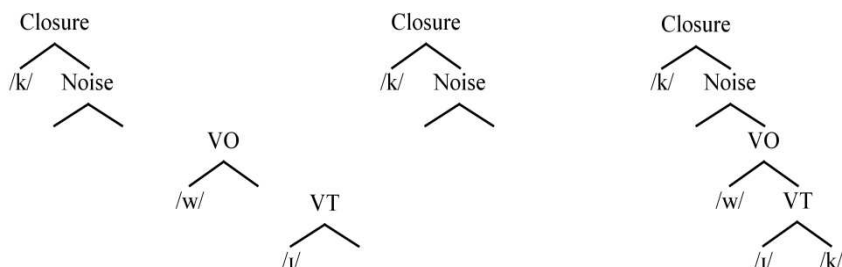
Despite the positive initial result found in our study, much more work remains to be done in two primary areas. First, additional acoustic descriptions should include the magnitude of formant excursion over the VC transition. This is a somewhat more complex methodological matter than simply measuring the duration of the transition. One possibility is to measure Euclidean distance in F1-F2 formant space, as is common practice in studies of diphthongs (e.g. Bogacka 2007) and diphthongization. We are planning a follow-up study in which this will be done while controlling for VC transition duration. The other area that needs to be pursued is the perceptual consequences of VC transitions in the two languages, as well as in the speech of L2 learners. For example, if the release burst is edited out of Polish-style tokens, will listeners still be able to identify the consonant? To what extent will this be based on English proficiency? These and other research questions will be posed in future work.

#### 4. The representation of ‘codas’ in the Onset Prominence framework

In the Onset Prominence environment, segmental representations and syllabic structures are derived from the same representational hierarchy, which has its origins in the phonetic events associated with a stop-vowel sequence in initial position. An important aspect of the OP hierarchy is that syllabic structure is not built-up from vocalic nuclei. Rather, it is built down from onset consonants, the most ‘prominent’ of which are stops. Thus, the top layer of the hierarchy is labeled Closure, the defining property of stops (and also present in nasal consonants). This followed by Noise, which is associated with both stop release and fricatives. The next level down is Vocalic Onset (VO), representing both approximants and glides, as well as the initial position of vowels that house CV transitions facilitating the perception of obstruents. At the bottom of hierarchy are vowels.

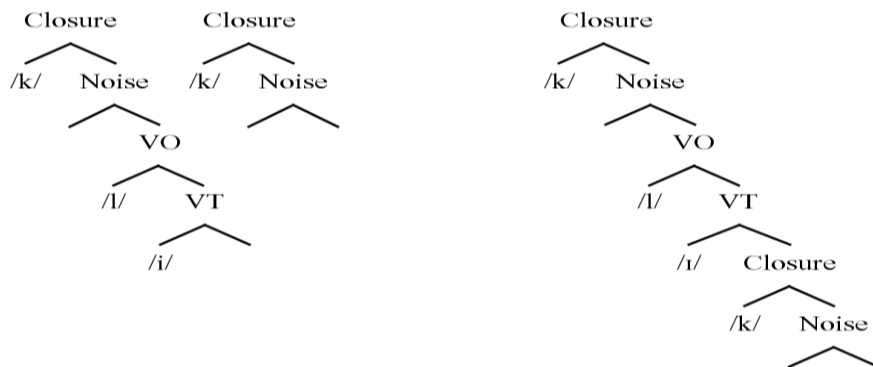
The relation between individual segments and prosodic constituents is seen in Figure 6, which shows individual segmental representations in the English word *quick* on the left, and a ‘syllabified’ representation on the right. In the individual structures each segment type as housed at different levels of the hierarchy. The stops are at the top, below them is the glide, and below that the vowel. The fundamental mechanism for building syllabic structures from individual segments is referred to as absorption, by which lower-level vowel structures are merged with higher-level consonants to make a single tree. By this mechanism, the /kwɪ/ sequence in *quick* is joined into a single tree. By contrast, the final /k/ may not be absorbed into the preceding constituent. In Figure 6

it is placed underneath the vowel as a result of a different process referred to as *submersion* (Schwartz 2013).



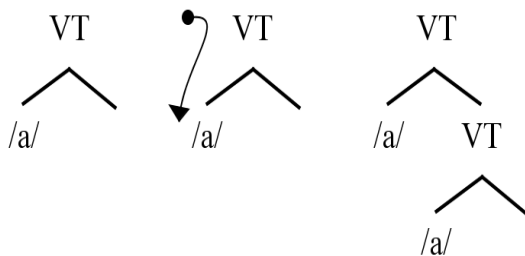
**Figure 6:** Segmental and constituent structures of English *quick*, with submerged final /k/

We suggest that the submersion process in *quick* is due to a parameter setting that enforces a more robust VC transition and allows for the possibility of unreleased stop. In Polish, submersion is hypothesized to be absent. The parametric difference is seen in Figure 7, which shows a representation of English *click* alongside the related Polish word *klik* (on the left). In *click*, the coda stop is at a lower level of the hierarchy and susceptible to lenition processes such as the suppression of stop release. The Polish coda /k/ remains at its underlying level, where release is obligatory.



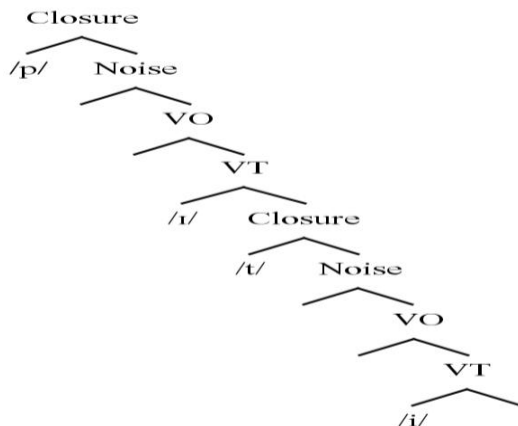
**Figure 7:** Polish *klik* (left) vs. English *click* (right) with submerged final /k/

While the representations in Figure 7 capture the cross-linguistic differences in coda stop behavior, the submersion parameter has prosodic implications that go beyond the mere question of stop release. Briefly stated, submersion is the same process that forms long vowels and vowel length contrasts, and creates VCV sequences in which the intervocalic consonant is subject to weakening processes. The vowel lengthening process is shown in Figure 8. Two adjacent vocalic structures, which may not undergo absorption since they are the same (VT) level of the OP hierarchy, may be joined by means of submersion producing a long vowel.



**Figure 8:** Submersion forming a long vowel

Figure 9 shows an additional case of submersion in the English word *pity*. In this case we see that not only single segmental structures, but also entire syllables may undergo submersion. Because of phonotactic constraints in English, the /t/ in *pity* is expected to syllabify as a coda, since lax vowels are always followed by a consonant in monosyllables. At the same time, universal onset maximization suggests that the /t/ should be an onset. This conflict gave rise to the controversial proposal of ambisyllabicity (Kahn 1976), by which the /t/ is shared by the two syllables in *pity*. The structure of *pity* in Figure 9 offers a natural expression of this ambiguity. The fact that the intervocalic /t/ is subject to weakening processes (flapping or glottaling) is a natural result of the consonant's lower position in the OP hierarchy.



**Figure 9:** English *pity* with submerged final syllable

We have seen that submersion unites three seemingly unrelated features of English phonology: the presence unreleased stops, the presence of long vowels, and consonant weakening processes in VCV sequences. Polish by contrast lacks all of these phonological properties. Coda stops are always released (except in homorganic clusters), vowel length is absent, and there is little or no consonant weakening in VCV contexts

(cf. Polish *PIT-y* ‘tax returns’). In sum, the submersion parameter makes insightful predictions about a number of independent facts that may be observed in the phonologies of Polish and English.

## 5. Final remarks

This paper has presented phonetic data on stop release production and unreleased stops in the speech of Polish learners of English. We identified a link between the suppression of stop release and the acoustic robustness of VC transitions. Briefly stated, more robust transitions that allow listeners to identify stops in coda position, accompanied the acquisition of unreleased stops in coda position. The phonetic study has far reaching phonological implications that may be described in the Onset Prominence framework.

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