PROSODICALLY-CONDITIONED SYLLABLE STRUCTURE IN ENGLISH*

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Abstract
This paper investigates the interplay between the metrical structure and phonotactic complexity in English, a language with lexical stress and an elaborate inventory of consonant clusters. The analysis of a dictionary- and corpus-based list of polysyllabic words leads to two major observations. First, there is a tendency for onsetful syllables to attract stress, and for onsetless syllables to repel it. Second, the stressed syllable embraces a greater array of consonant clusters than unstressed syllables. Moreover, the farther form the main stress, the less likely the unstressed syllable is to contain a complex onset. This finding indicates that the ability of a position to license complex onsets is related to its distance from the prosodic head.

Keywords: English, lexical stress, onsets, phonotactics

1. Introduction

Traditionally, syllable weight has been associated with rhyme. In *The Sound Pattern of English*, Chomsky and Halle (1968) stated that stress is attracted to heavy syllables, defined by means of a rhyme structure, where onset is considered not to affect stress placement. This observation was confirmed in a large body of cross-linguistic research (e.g. Clements and Keyser 1983; Halle and Vergnaud 1987; Hyman 1985; Hayes 1995; Selkirk 1984). However, the studies that followed reported on systems in which not only the presence of onset but also its quality determine the position of stress. For instance, in Western Aranda, an

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Australian language, words composed of more than two syllables are assigned initial stress if they start with a consonant (Davis 1988). A similar pattern was found in Pirahã, an Amazonian language, where the voice specification of onset consonants affects the stress placement (Everett and Everett 1984). Recent comprehensive overviews of such systems additionally list Karo, Banawã, and Dutch (see Topintzi 2010 for references and discussion).

Although English has been generally mentioned among languages which exhibit no interaction of stress with the onset quality or the presence of onset, recent studies (Kelly 2004; Ryan 2014) have revealed that onset complexity (i.e. length) is a significant attractor of stress in English bisyllabics. In the present study, we examine the correlation between stress placement and the structure of word-initial onsets in polysyllabic words with the main stress located on different syllables (word-initial, word-medial and word-final). Note that complexity is understood here in terms of the number of adjacent consonants, and it ranges from a zero onset (onsetless), through a simplex onset (represented by a single consonant, C) to a complex onset (represented by a cluster of consonants, CC and CCC).

2. State of the art

Kelly (2004) reported on three studies investigating the relationship between word-initial onset length and stress pattern. Firstly, the analysis of a corpus-based list of 6 862 items (including 4 126 trochaic and 2 736 iambic words) demonstrated that the first syllable (or trochaic) stress propensity is significantly related to the number of consonants word-initially. The tendency is expressed by means of trochaic proportions, which ascend from 0.35 through 0.69 and 0.83 to 0.98 for zero-, one-, two- and three-member onsets, respectively. The same tendency was observed in psycholinguistic data and in poetry. Kelly (2004) showed that in a judgement test English speakers relied on word onset structure in determining the stress of nonce bisyllabics, thus suggesting that the association between onset complexity and stress placement is part of native speakers' phonological representation. Finally, onset structure was shown to affect the alignment of words with stressed positions in John Milton's *Paradise Lost.* Generally, these findings indicate that onset patterns can have wide ranging effects on English prosody.

Building on the contribution of Kelly (2004), Ryan (2014) analysed a larger set of morphologically simplex English bisyllabics (N = 8 323), extracted from CELEX (Baayen et al. 1993), controlling for variables such as part of speech (noun, adjective, verb), frequency range (low, middle, high), onset structure (zero, C) and rhyme structure (a short vowel V, CV, a long vowel or a diphthong VV). Overall, there is a significant correlation between stress placement and word onset structure, which persists across all the major subdivisions of the lexicon. A summary of the results is presented in Figure 1. The percentages refer to bisyllabic words stressed on the initial syllable with initial onset length varying from zero onset (labelled 0) to a three-member consonant cluster (labelled 3).

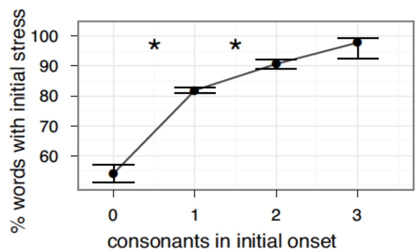

Figure 1: Stress placement in English bisyllabics of varying onset structure (Ryan 2014: 311)

The ascending line confirms that the incidence of initial stress increases monotonically with an increase in onset complexity. That is, the more complex the onset, the more likely the syllable is to carry primary stress. Each asterisk in the plot indicates a significance level of a pairwise comparison between the proportions below it (with 95% confidence intervals). As can be observed, the differences between onset zero and C, as well as between C and CC are significant. With these results in mind, we pursue an analysis which looks into the correlations between the onset type and stress pattern on a more exhaustive and varied dataset.

3. Present study

The present study examines the relationship between stress patterns and onset complexity. Emphasis is placed on onset clusters found in the word-initial syllable only. Target words collected for the purpose of the study vary in length from one to eight syllables. Such a rich and varied inventory of words makes it possible to investigate the relation not only in a binary contrast between stressed and unstressed syllables (cf. Kelly 2004; Ryan 2014), but also accounting for the degrees of distance from the main stress, in line with Orzechowska et al. (2018). We are particularly interested in finding out whether the complexity of the initial onset is affected by its distance from the main stress. The following labelling convention has been adopted, where the initial syllable is underlined (_), and the primary stress is marked with an apostrophe ('):

(1)	a.	*bisyllabics*	
		'al.mond	– 0 distance between onset and stress
		re. 'verse	– 1 distance
	b.	*trisyllabics*	
		'bi.tter.ness	– 0 distance
		em. 'ploy.ment	– 1 distance
		pro.me. 'nade	– 2 distances
	c.	*tetrasyllabics*	
		'bu.dge.ta.ry	– 0 distance
		e. 'mo.tion.less	– 1 distance
		co.ro. 'na.tion	– 2 distances
		te.le.gra. 'phese	– 3 distances

3.1. Data

The data were extracted from two resources, a dictionary and corpus. The list of unique words was extracted from the 85 000-entry *Oxford Advanced Learner's Dictionary of Current English* (henceforth ALDCE, Hornby 1974). We eliminated proper nouns, abbreviations and duplicated entries, which resulted in the total of 26 614 uninflected lexical entries stressed on the first syllable, and starting either with a vowel (onsetless), a simplex onset (C) or a complex onset (CC, CCC). The data included compounds and morphologically complex words belonging to different parts of speech. The final word list contained 26 614 lexical items, including 3 730 monosyllabics, and 22 884 polysyllabics.

The dictionary data provided us with word type frequencies, where each lexical item had the frequency equal to one. In order to complement the analysis with a richer dataset, token frequencies for the word list were extracted from the 410 million-word *Corpus of Contemporary American English* (henceforth COCA, Davies 2011). This corpus of newspaper texts contained words and their repetitions, reaching a total of 239 291 747 word tokens, among which 159 467 346 monosyllabics and 79 824 401 polysyllabics were found.

3.2. Results

Below, we summarize the results of the analysis for words of various lengths composed of up to eight syllables. Sections 3.2.1 to 3.2.5 report on the ALDCE data where word type frequencies are given, while section 3.2.6 generalizes over the corpus-based token frequencies. In each table, the Onset (O) column specifies an onset type of the word-initial syllable, which can have the following structure:

(2) a. onsetless (labelled 0)
b. simplex (containing a singleton consonant; labelled 1)
c. complex (containing a sequence of consonants CC, CCC and CCCC; labelled 2, 3 and 4, respectively).

The distance column (Dist) presents the number of words with a specific distance between the stressed syllable and the first syllable, ranging from one to five. Distance zero (Dist 0) represents words stressed on the first syllable (e.g. *'tro.lley, 'ar.bi.tra.ri.ness*), while distances one to three (Dist 1-3) embrace words with the main stress on the second, third and fourth syllables (e.g. *beau. 'ti.cian, in.di. 'vi.dual, im.po.ssi. 'bi.li.ty*), respectively (see section 3). Tables 1-5 report on the number of words (No), and percentages (%) calculated for the total of words with a particular stress pattern (Σ). For instance, in bisyllabics (see Table 2) with trochaic stress ['..] (Dist 0), 9% of words have no onset, 69% start with C, 21% start with CC, and only 1% of words contain a CCC-initial cluster. In bisyllabics with iambic stress [.'.] (Dist 1), 36%, 56% and 8% of words contain zero, one or two consonants, respectively. Only two lexical items with iambic stress start with a three-member cluster.

In order to verify whether the differences observed in Tables 1-5 hold, a statistical analysis was performed. The Pearson's chi-squared test (χ^2) demonstrates that the differences between onset length and stress placement are statistically significant at a high level ($p < .000$). It must be noted that χ^2 does not operate on low numbers. Therefore, only categories represented by more than five words were entered into the analysis.

3.2.1. Monosyllabics

The discussion of the results starts with words composed of a single syllable, all of which are characterized by a distance of zero (Dist 0). In other words, all monosyllabics have primary stress. Therefore, Table 1 shows the distribution of various onset types in stressed syllables, and constitutes the baseline for the comparison with longer words.

Table 1: Monosyllabic words in the dictionary (*N* = 3 730)

	Dist 0	
Onset	**No**	**%**
0	129	3
1	2 338	63
2	1 154	31
3	109	3
Σ	3 730	100

As can be observed, the majority of monosyllabics starts with a single consonant (63%). The number of words gradually decreases from 63% to 3% along with the increase in onset complexity from C to CCC. Onsetless initial syllables constitute a minority, and are found only in 3% of the monosyllabic words under investigation.

3.2.2. Bisyllabics

In bisyllabics, the unstressed position (Dist 1) contains fewer words with an initial consonant cluster than the stressed one (Dist 0). That is, more words start with a sequence of two or three adjacent consonants when the initial syllable is stressed ($p < .001$). As is shown in Table 2, the proportion of CC(C) in a stressed syllable in relation to an unstressed syllable amounts to 11:1 (1 742 to 161) for CC and 60:1 (119 to 2) for CCC. This relation can be also expressed by trochaic proportions (labelled TP), which increase with the number of consonants in the word onset.

Table 2 Bisyllabic words in the dictionary (N = 10 493) with initial main stress as a function of initial onset complexity

	Dist 0		**Dist 1**		
Onset	**No**	**%**	**No**	**%**	**TP**
0	730	9	742	36	.49
1	5 850	69	1 147	56	.83
2	1 742	21	161	8	.91
3	119	1	2	0	.98
Σ	8 441	100	2 052	100	

The results are in accordance with the previous findings in Kelly (2004) and Ryan (2014), where onset complexity was demonstrated to attract stress in English bisyllabics. It must be noted that the propensity of cluster-initial words to exhibit a trochaic pattern is greater in shorter words. Therefore, in order to establish whether the same tendencies hold over the entire lexicon in English, below we detail the analysis for polysyllabic words.

3.2.3. Trisyllabics

Similarly to trochaic bisyllabics, trisyllabics accented on the first syllable feature more complex onsets ($p < .001$). In addition, the data in Table 3 show that the distance is correlated with the degrees of phonotactic complexity; greater proximity to the stressed syllable guarantees greater tolerance of consonant clusters. At the same time, the farther away from the main stress, the greater the number of onsetless syllables. The same tendency, although less pronounced, was observed in the group of bisyllabics.

Table 3: Trisyllabic words in the dictionary (N = 7 126) with initial main stress as a function of initial onset complexity

	Dist 0		Dist 1		Dist 2	
Onset	**No**	**%**	**No**	**%**	**No**	**%**
0	736	19	961	37	304	48
1	2 522	66	1 400	53	298	47
2	559	14	273	10	35	5
3	29	1	8	0	1	0
Σ	3 846	100	2 642	100	638	100

3.2.4. Tetrasyllabics

The results obtained for tetrasyllabics strengthen the findings reported in sections 3.2.2 and 3.2.3. The number of words with an initial CC cluster decreases monotonically along with the increasing distance from the main stress ($p < .001$). No generalizations can be formulated for words starting with a three-member cluster, as the data features only seven such examples.

Table 4: Tetrasylllabic words in the dictionary (N = 3 683) with initial main stress as a function of initial onset complexity

	Dist 0		Dist 1		Dist 2		Dist 3	
Onset	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
0	144	23	618	40	580	40	24	41
1	414	65	781	50	753	53	34	57
2	77	12	152	10	98	7	1	2
3	1	0	2	0	4	0	–	–
Σ	636	100	1 553	100	1 435	100	59	100

3.2.5. Longer words

The analysis of words composed of five to eight syllables did not reveal uniform results. In pentasyllabics, complex onsets occur in 8% of words with the main stress on the initial syllable, and in 5%, 7% and 9% of words with the stress moved to the left by one, two, and three syllables, respectively (no word starts with a complex onset when the main stress is located on the fifth syllable). In hexasyllabics, words stressed on the first or second syllables do not contain word-initial complex onsets. In the remaining cases, complex onsets occur in 2% of words with the stress on the third syllable, in 8% of words with the stress on the fourth syllable, and in 8% of words with the stress on the fifth syllable. No word-initial complex onsets are attested in hepta- and octosyllabic words.

3.2.6. Token frequencies

This part of the analysis consists in testing the correlations on the corpus data. Token frequencies represent the multiple occurrence of individual words in a large data resource. The comparison of the results obtained for types and tokens allows us to detect any bias resulting from the disproportionate high frequency of a small group of words. For instance, *draughty* and *grotty* occur 10 and 25 times in the corpus, while the number of occurrences of *question* and *study* amount to 132 806 and 128 326, respectively. Most importantly, the COCA data yields results comparable to the ALDCE data.

First, monosyllabics tend to start with a singleton C (80%). The number of word types decreases gradually from 80% to 0% as the length of word onset increases from C through CCC. Words containing vowel-initial onsets constitute 12% of the monosyllabic words. Second, the results obtained for bisyllabics, trisyllabics and tetrasyllabics confirm that there exists a relationship between the distance from the stressed syllable and onset length. That is, the closer to the main stress, the larger the number of words with heavier onsets. For instance, in bisyllabics with trochaic stress, 22% of words have no onset in the initial syllable, 65% start with C, 12% start with CC, while only 1% contains a CCC-initial cluster. In bisyllabic words with iambic stress, 45%, 52% and 3% of words contain zero, one or two consonants, respectively. Fewer than 1% of lexical items with iambic stress start with a CCC cluster. The distributional patterns for trisyllabics are provided in Table 5. These findings, too, parallel the results obtained for the dictionary data.

Table 5: Percentages of three-syllable words in the corpus (N = 17 770 978) with initial main stress as a function of initial onset complexity

	Dist 0		**Dist 1**		**Dist 2**	
Onset	**No**	**%**	**No**	**%**	**No**	**%**
0	2 245 857	24	3 316 667	43	351 366	60
1	6 031 615	63	3 775 475	49	226 666	38
2	1 144 645	12	575 218	8	13 160	2
3	72 464	1	17 845	0	–	–
Σ	9 494 581	100	7 685 205	100	591 192	100

3.2.7. Complexity of consonant clusters

In the preceding subsections, we have examined the relationship between stress placement and onset complexity in terms of length. We are also interested in the variety of onset types, in particular the consonant clusters that each prosodic position can support. Table 6 lists the number of different C, CC and CCC types found in the dictionary word list. It must be borne in mind that the numbers refer to the presence of a simple onset (1) or a complex onset (2, 3) word-initially.

Table 6: The distribution of onset cluster types across distances

Onset	Dist 0	Dist 1	Dist 2	Dist 3	Dist 4	Dist 5
1	23	22	22	17	13	4
2	46	30	26	17	4	–
3	8	5	3	1	–	–
Σ	77	57	51	35	17	4

Overall, the stressed position (Dist 0) supports the greatest array of cluster types. As the distance from the main stress increases, the number of different C, CC and CCC onset types decreases. As shown in Table 6, the tendency is the strongest in two-member sequences; 46 different types are found in the prosodically strongest position, in contrast to only several types found four syllables away from the primary stress. Distance 6, although reported in section 3.2.5, does not support any consonant clusters, and is therefore excluded from the table.

What is more, the same observations have been made for each individual cluster. Namely, the number of words starting with a specific CC(C) onset decreases from Dist 0 to Dist 5. For example, /pr/ occurs initially in the greatest number of words (Σ = 564), and is supported best in the Dist 0 position (253 words), followed by Dist 1 (227 words), Dist 2 (64 words), Dist 3 (18 words) and finally Dist 4 (2 words). The only exceptions to the pattern are the clusters /wv/ and /skl/, which appear in loans stressed on the second syllable *voyeur, voyeurism* and *sclerosis*.

Accounts of English phonotactics list between 50 and 60 onset or word-initial clusters (Cruttenden 2014; Roach 2006; Trnka 1966; Zydorowicz et al. 2016) depending on the treatment of rare words (e.g. /θj/ in *thurible,* /sv/ in *svelte*) and loans (e.g. /zl/ in *zloty, /*ʃn/ in *schnapps*). As can be observed, stressed onsets (Dist 0) make use of a substantial portion of all the existent clusters (i.e. 54 CC(C)). Similarly, stressed syllables with simple onsets allow 23 out of 24 singleton consonants available in the language (see Roach 2004 and Hillenbrand 2003 for descriptions of the British and American inventories, respectively), with the exception of velar nasals, which are banned from the onset position.

3.2.8. Voicing as a stress predictor

Topintzi (2010) reports on languages in which primary stress is correlated with a voiceless segment in the onset. To test the correlation in English, we inspected the voicing feature of a singleton onset C and the first consonant in CC(C) clusters for the stressed position only (Dist 0). Table 7 summarizes the results, where a voiced segment is labelled with the plus sign (+) and a voiceless segment with the minus sign (–). Table 7 lists the number of segment types with a particular laryngeal feature (Segment) and word types representing them (Word). The data shows that singletons are largely represented by [+voice] consonants, while clusters tend to start with a [–voice] consonant. This result can be attributed to the phonotactic constraints operating in English (Cruttenden 2014; Roach 2006), whereby the cluster-initial slot tends to be occupied by a voiceless obstruent.

Table 7: Voice contrast in stressed syllables

	C		CC		CCC	
Voice	**Segment**	**Word**	**Segment**	**Word**	**Segment**	**Word**
+	16	6 790	14	861	0	0
-	7	4 372	33	2 676	7	258
Σ	23	11 162	47	3 537	7	258

When we consider the voicing of obstruents, the pattern becomes even clearer. Table 8 presents the number of words starting with voiced and voiceless plosives, fricatives and affricates. To avoid a phonotactically-based bias, calculations are based on singleton onsets only. The results reveal a correlation between the primary stress and voicelessness. That is, onsets with a [–voice] feature outweigh their [+voice] counterparts, conforming the predictions of Topintzi (2010). The tendency holds across all the voiced-voiceless pairs with the exception of /ʧ/ vs. /ʤ/.

Table 8: Voiced and voiceless obstruents in simple onsets

Voiceless C	Word	Voiced C	Word
p	952	b	829
t	670	d	601
k	1 014	g	351
f	677	v	300
s	1 052	z	32
θ	88	ð	11
ʃ	231	ʒ	4
ʧ	200	ʤ	247

4. Discussion

This contribution examines the complexity of onsets in prosodically strong and weak positions, and in relation to their distance towards the stressed syllable. Apart from investigating the binary contrast between stressed and unstressed syllables, which was pursued in previous contributions on the topic, the current study explores the idea of degrees of positional complexity. Our data lead to three major observations.

First, there are a larger number of word-initial onsetless syllables in prosodically recessive positions. For words composed of two, three and four syllables, the number of zero onsets increases monotonically as the distance from the primary stress increases. For instance, in bisyllabics, the proportion between onsetless syllables in the stressed position (Dist 0 = 9%) and in the unstressed position (Dist 1 = 36%) equals 1:4. This is a static distribution; nevertheless, the pattern is similar to the one attested in Aranda, in which a syllable with an onset is more likely to carry stress than an onsetless one (Topintzi 2010).

Second, the analysis demonstrates an asymmetrical distribution of consonant clusters, with more complex onsets in stressed syllables. Generally, CC and CCC sequences are more likely to occur in the strong syllable. For trisyllabics, 16% of the initial syllables contain CC(C), compared to 10% in the immediately pretonic position and 5% in the position removed from the main stress by two syllables. Quadrisyllabics display the same pattern: stressed syllables contain 12% of complex clusters, and pretonic syllables have 10% (Dist 1), 7% (Dist 2) and 2% (Dist 3) of complex clusters. Also, an inspection of the distribution of different cluster types reveals that pretonic syllables display more varied cluster types than atonic syllables. For instance, stressed syllables host 54 different CC and CCC sequences, in opposition to unstressed syllables.

Finally, the data suggests that, similarly to other languages described in the subject literature, English exhibits a correlation between stress and laryngeal features. Stressed onsets tend to start with a voiceless obstruent. This observation holds not only for singleton segments but also for consonant clusters.

5. Conclusions

Although English has been mentioned among the languages which do not exhibit an interaction of stress with either the onset quality or the presence of an onset, this study reveals that the distribution of onsetless syllables is correlated with the position of stress. First, stressed syllables support not only more complex onsets in terms of length but also a greater array of consonant clusters. Weak syllables, in turn, repel clusters and favour empty onsets or onsets composed of a singleton consonant. Second, the proximity to the stressed syllable also shows to be a predictor of onset complexity; a variety of complex onsets increases as the distance towards the stressed syllable decreases. Overall, the results of the study tip the balance in favour of theories stating that not only the rhyme, but also the onset can play a role in determining the weight of syllabic constituents.

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