Phonologically Governed Allomorph Selection: The Choice of *-ce*/*-cy* in English based on Stress and Syllable Structure

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The purpose of this study is to examine how English speakers' phonological system plays a role in morphological selection. This study is focused on explicit investigation of English speakers' intuition regarding English allomorph selection along with prosodic structure and stress pattern. Specifically, this study deals with the speakers' preferences to the choice of the *-ce*/*-cy* ending nouns from their *-ant*/*-ent* ending English adjective bases. For instance, some *-ant*/*-ent* ending adjectives adopt *-ce* for their noun forms as in *convenient* to *convenience* (not **conveniency*), while others adopt *-cy* as in *efficient* to *efficiency* (not **efficience*). In this work, I suggest an Optimality Theoretic account of English stress rules and provide the general stress patterns of English adjectives, by discussing prosodic structures of the bases regarding syllable structure and weight. The account is evaluated with empirical survey data, which verifies English speakers' selectional preferences in English noun allomorphy.

Keywords: allomorph selection, Optimality theory, English stress rules, phonology, morphology

1. Introduction

Identical morphemes in a language are often realized in different forms and these morphemes are known as allomorphs. It is widely known that the morphological realizations of an allomorph (i.e., the choice of a specific morpheme amongst more than one candidate) depend on the phonological contexts in which they appear. That is, there are certain preferences regarding the phonological conditions under which different allomorphs are selected. These preferences are known as selectional properties of

morphemes.

These selectional properties have been discussed not only in terms of morphology but also in terms of its closely related area, phonology. They have been considered within the framework of these two subdisciplines of linguistics, and many languages have been discussed in the literature (McCarthy & Prince 1993, 1998; Plag 2003; Lappe 2007, among others). Drachman *et al.* (1995), for example, suggested that the phonological structures of the base result in the preference for a specific affix over other morphologically possible alternatives. They showed Russian diminutive allomorphy wherein the allomorph selection of [-(o)k], [-ik], [-(ə)k/-(i)k] are determined by the interactions of stress, syllable structure and segmental properties of the base. In addition, the systematic distribution of English plural marker [-s], [-z] and [-əz] is another example of showing phonology-dependent suffixation. Being realized as [-z] after voiced consonants, [-s] after voiceless and [-əz] after sibilants reflects the choice of allomorphs heavily depends on the phonological conditions of the bases (Martin 2002).

These studies point out that the phonological context of the base determines which allomorphs are selected. In other words, the morphological selection of allomorphy interacts with phonological condition of the base. Allomorph selection is not random and it cannot be discussed without concerning the phonological structure of the base. The phonological conditions of the base largely involve prosodic structures such as syllable structures, syllable weight and stress assignment.

There is abundant research to show the interaction between the prosodic structure and allomorph selection. The research so far has described the data and provided a theoretical analysis for the phenomenon. What is lacking in the research is the empirical data to validate the theoretical analysis. This study aims to provide an explicit and theoretical analysis of English noun allomorph selection and to verify the analysis with empirical mini-survey data.

Specifically, in this study, I examine English noun allomorphy *-ce/-cy* endings for their adjective bases *-ant/-ent* [-ənt] endings. I argue that the choice of allomorph has to do with the stress assignment patterns. In particular, it is observed in this paper that (i) English allomorphy is prosodi-

cally governed, that (ii) the stress patterns are sensitive to syllable structure and weight, and that (iii) the same patterns are found in nonce words as well. Based on these observations, it is suggested that English noun endings are phonologically conditioned, as many allomorphs are, on the basis of the prosodic structures of the base.

This study provides an Optimality Theoretic account in describing the interaction between the stress pattern and syllables. Candidates that were possibly relevant to stress assignment and their power were computed in OTsoft (Hayes, Tesar & Zuraw 2003). After discussing the grammatical analysis on English real words, the study examines the analysis ofpossible English nonce words. The results of the nonce words are compared with distributional generalizations of real words in order to examine whether English speakers apply the same stress rules and allomorph selection strategies onto English non-words. English speakers' application of the same strategies to the English nonce words will explain English speakers' lexical preferences in allomorph selection.

This paper is organized into four sections. The next section begins with introducing English noun *-ce/-cy* ending allomorphy. It also explains the general stress algorithm in English. Section 3 deals with the theoretical accounts of English stress patterns along with English noun allomorphy. The empirical data from mini survey results are provided in this section. Finally, section 4 concludes the study.

2. Stress and Allomorph Selection

2.1. English allomorph selection: *-ce* vs. *-cy*

The focus of this study is English noun allomorphy, specifically, the choice of *-ce* or *-cy* from *-ant* or *-ent* ending adjectives as in the following examples, in which the allomorphic distributions from two different bases are provided. Note that in order to examine the interaction of the phonological system of the bases and the choice of allomorphs, the discussion of this study is limited to trisyllabic bases (adjectives).

(1) Selectional properties of *-ce* vs. *-cy* allomorphy

a.	*reverent*	*reverence*	**reverency*
b.	*efficient*	*efficiency*	**efficience*

The two example words provided in (1) show that the two English noun endings *-ce* and *-cy* are allomorphs and that there is a preference for one to the other according to the adjective. For instance, the adjective *reverent* adopts *-ce* as in *reverence* rather than **reverency*, while the adjective *efficient* becomes *efficiency* instead of **efficience* by adopting *-cy*. These examples may be understood to show that English words have selectional properties: English adjectives that end with either *-ant* or *-ent* adopt a specific derivational morpheme either *-ce* or *-cy* as their noun ending.

In general, no meaning contrast is found among allomorphs, and *-ce* and *-cy* do not have the contrast as well (except for a few cases such as *dependence* vs. *dependency*). However, a different kind of contrast between the two allomorphs has to be noted in order to examine what makes the opposed selectional properties possible. The main difference between *-ce* and *-cy* arises from whether or not the morpheme is a syllable. The *-ce* ending consists of a single segment; simply a consonant [-s], while the *-cy* ending has both a consonant and a vowel [-si]. In other words, the *-cy* ending has a syllabic segment. When attached to the bases, the *-cy* ending extends the total number of syllables, while the *-ce* ending does not. This difference shows that the two allomorphs contrast in terms of segmentism and syllable counts. In other words, the *-cy* suffixation increases the numbers of syllables, which in turn results in a change of the overall prosodic structures of the adjective base. On the other hand, the *-ce* ending does not affect the number of syllables.

In addition to the fact that the two allomorphs of *-ce* or *-cy* differ regarding their syllable numbers, it also should be noted that the allomorph selection results in different consequences. Since the stress placement rules in English entirely operate according to syllabic structures, the adaptation of *-ce* or *-cy* strongly influences the general stress assignment of the base. In the following section, let us describe how the difference in syllable number plays a role in English noun allomorph selection.

2.2. English stress rules

English is known as a stress-sensitive language, and English stress patterns are determined by syllable structure and weight (Halle & Vergnaud 1987; Hayes 1989, 1995; Roca & Johnson 1999). In many languages, such as English and Spanish, it is usually the case that the stress of a word falls on one of the last three syllables. English word stress is believed to be complex and irregularities are frequently found. However, English stress is also considered to be predictable in many contexts (Arndt-Lappe & Plag 2013). In various research as in Kager (1989) and Roca & Johnson (1999), it is reported that the English stress algorithm generally conforms to the following rules summarized in (2).

(2) English Stress Placement Rules
(Kager 1989; Roca & Johnson 1999)
a. All lexical items have a stress. e.g., *pút*
b. If the final vowel is long, it is stressed. e.g., *kangaróo*
c. Heavy penults are stressed. e.g., *agénda* (Mester 1994);
Light penults are antepenult-stressed. e.g., *Cánada*
d. "Maximality of Stress Placement: Stress is on the antepenult whenever it can, otherwise on the penult" (Kager 1989: 29). e.g., *América*

In examining these rules, one should notice that English stress placement operates according to the three-syllable window and the syllable weight. The general idea of Englishmstress placement rules is that 'if penult is heavy, stress on penult. Otherwise, antepenult stress.' That is, in English, heavy penults are to be stressed and light penults results in antepenults being stressed.

Arguably, English stress placement rules may be applied to our English noun allomorph selection. The adjective form [-ənt] from the '*-ant/-ent'* ending has a heavy ultimate syllable with two coda consonants. Since the ultimate syllable of the base is invariant for [-ənt] adjectives, let us mark this syllable as X. Both penultimate and antepenultimate syllables of bases can be either heavy (H) or light (L). The configurations of H,

L and X generate 4 types of syllable structure as described below:

(3) Syllable weight and configurations

antepenultimate	penultimate	ultimate	configurations
L	L	X	LLX
	H		LHX
H	L		HLX
	H		HHX

In principle, one syllable of each word bears the primary stress. Stress placement along with the four configurations leads to the eight computations of stress and syllable weight in (4).

(4) Eight Patterns by Stress Placement and Syllable Weight (Ahn 2014)

Patterns	Example words	Nominalized
1. Ĺ L X	*réverent*	*réverence*
2. L Ĺ X	*efficient*	*efficiency*
3. Ĥ L X	*ábstinent*	*ábstinence*
4. H Ĺ X	*incéssant*	*incéssancy*
5. L Ĥ X	*abúndant*	*abúndance*
6. Ĺ H X	N/A	
7. H Ĥ X	*obsérvant*	*obsérvance*
8. Ĥ H X	N/A	

The combination of L or H syllables and with or without stress generates 8 patterns and they are ĹLX, LĹX, ĤLX, HĹX, LĤX, ĹHX, HĤX and ĤHX as described in the first column of (4). Among these eight patterns, Pattern 6 ĹHX and Pattern 8 ĤHX are not attested in real English corpus data (Ahn 2014). The second column shows example words of each pattern and their noun forms in the third.

Now, let us examine these eight patterns of syllable structures and stress

combinations. Among these eight patterns, Pattern 1, 3, 5 and 7 may be said to conform to the general English stress rules either by light penults yielding stress to antepenults (Pattern 1 and 3) or by heavy penults being stressed (Pattern 5 and 7). These patterns with so-called '*optimal*' stress placement in adjectives select the *-ce* ending. By selecting the *-ce* ending allomorph, the *'already-optimal'* phonological structure is not affected by the allomorph selection. This is due to the fact that the *-ce* ending does not add any syllables after the ultimate of the base.

On the other hand, Patterns 2, 4, 6 and 8 do not correspond to the suggested stress placement rules. Light syllables being stressed regardless of other adjacent syllables is not optimal. That is, according to the rule, if the penultimate is light, the antepenultimate is stressed; thus, Pattern 2 and 4 violate this rule, which indicates that the stress patterns should be modified to be more acceptable.

Interestingly enough, the patterns in 2 and 4 with so-called *'less optimal'* phonological structures, in fact, adopt the *-cy* ending in allomorph selection. By adopting *-cy* ending instead of *-ce*, another syllable is added to the base and the total number of the syllables of the base is increased. More importantly, this process of adopting *-cy*, has the effect of shifting the stress one syllable leftward. This structural change of modifying the phonological condition of the base may be interpreted as a strategy to avoid the '*less optimal*' stress placement.

3. An Optimality Theoretic Approach

3.1. OT constraints

In this section, a theoretical analysis of English stress rules is discussed. As a theoretical approach, we adopt the constraint-based grammar of Optimality Theory (Prince and Smolensky 2004). It explains the English stress algorithm along with the interaction of faithfulness and markedness constraints. The primary constraints that are frequently discussed in stress assignment are summarized in (5).

(5) FT-BIN: Feet are binary under moraic or syllable analysis. (Kager 1999)
NON-FIN: The stress foot cannot be final. (McCarthy 2002)
TROCHEE: A foot is left-headed.
PARSE: All syllables belong to feet. (Pater 2000)
ALI-F-R: Every foot stands at the right edge of the PrWd. (Kager 1999)

This set of prosodic markedness and faithfulness constraints can be understood as follows: the combinations of syllables are organized into feet, a basic metrical unit for rhythmic patterns. This combination, however, is not random. These constraints have to do with the cross-linguistic preference regarding rhythm. The fundamental requirement of rhythmic patterns is 'regular alternation of strong and weak syllables' (Kager 1999: 161). It defines feet having to be binary and this requirement is captured by FT-BIN. According to Kager, the key function of this constraint is to exclude degenerate feet that contain a single light syllable. Non-binary feet are penalized by this constraint (i.e., ($\sigma\sigma$) rather than (σ)).

In addition to the constraint introducing alternating patterns, as for English stress, NON-FINALITY has to be introduced. This constraint determines the rhythmic shape of English trochaic feet, which requires a stressed syllable followed by unstressed one (McCarthy and Prince 1986; Hayes 1987, 1995; Kager 1993). That is, it penalizes an input that places the stress foot on its final syllable and forces the final syllable to avoid the metrical parse (i.e., ($\sigma'\sigma$) rather than ($\sigma\sigma'$)).

A quantity-sensitive constraint is involved as well. Quantity has to do with weight-bearing units, known as moras (Van der Hulst 1984; Hyman 1985; Hayes 1989). The number of moras represents syllable weight: universally, long vowels (i.e., CVV) are represented by two moras and short ones (i.e., CV) by one. A syllable with two moras is known to be bimoraic and it is called heavy, while one with one mora is monomoriac, a light syllable. A bimoraic heavy syllable is expressed by CVC syllables, indicating that the coda is moraic.

The above constraints enforce rhythmic binarity. However, they do not necessarily guarantee feet generation because unparsed underlying segments may exist. PARSE requires all syllables to be parsed into syllable structure (Hayes 1980; Halle and Vergnaud 1987; Prince and Smolensky

2004). Thus, an unparsed final syllable violates PARSE.

The rhythmic distribution of feet is determined by TROCHEE and ALIGN-FOOT-RIGHT. TROCHEE requires prosodic units to be left-headed; thus, a metirical foot of strong-weak is preferred to weak-strong. The alignment constraint has the effect of fixing one edge of the word toward a foot. In English, the alignment of the word and the foot is anchored on the right edge (Kager 1999). ALI-F-R is satisfied when the right edge of every foot coincides with the right edge of a PrWd.

3.2. Constraints interaction

The interaction of these five constraints generates a ranking hierarchy. The hierarchy was computed by OTSoft (Hayes, Tesar & Zuraw 2003). OTSoft is 'a Windows program meant to facilitate analysis in OT'. This constraint ranking software works as follows: if a user provides the relevant constraints with the evaluation of each constraint – the frequency of violations, it performs the permutation with the provided constraints. Once the user uploads the input file, the program calculates the ranking hierarchy. The output script in (6) contains the permutations of constraints, the ranking arguments and necessary constraints with tableaux. Through this computational process, the interaction among constraints is explicitly expressed.

The English *-ant/-ent* ending adjective data were entered in OTSoft and they were processed through the program. The generated ranking hierarchy and the computation of the constraints are reported in the tableaux below. Each number provided in the tableaux corresponds to the number of violations from each input with respect to a specific constraint.

(6) Pattern 1 (ĹLX), 3 (H́LX), 5 (LH́X) and 7 (HH́X)
FT-BIN, NON-FIN, PARSE, TROCHEE » ALI-F-R

INPUT	Candidates	Optimal Output	CONSTRAINTS				
			FT-BIN	NON-FIN	PARSE	TROCHEE	ALI-F-R
réverent	(réve)<rent>	1					1
	réve<rent>				2		
	[(ré)(ve)]<rent>		2				3
	(réve)(rent)			1			1
ábstinent	(ábsti)<nent>	1	1				1
	ábsti<nent>				2		
	[(áb)(sti)]<nent>		1				3
	áb[(sti)(nent)]		1	1	1	1	1
abúndant	[(a)(bún)]<dant>	1				1	3
	abún<dant>				2		
	(abún)<dant>		1			1	1
	(a)[(bún)(dant)]		1	1			3
obsérvant	[(ob)(sér)]<vant>	1				1	3
	obsér<vant>				2		
	(obsér)<vant>		1			1	1
	(ob)[(sér)(vant)]		1	1			3

The four words provided in the tableaux are examples from Pattern 1 (ĹLX), 3 (H́LX), 5 (LH́X) and 7 (HH́X), respectively. They all can be well explained with the relevant ranking, and they all adopt the *-ce* ending for their noun allomorphy. On the other hand, the alternative patterns in Pattern 2 (LĹX) and 4 (HĹX) cannot be correctly explained by the same ranking hierarchy. Both Patterns 2 and 4 incur fatal violations of a constraint, TROCHEE. Thus, the stress placement of the two patterns does not comply with general English stress rules and they adopt *-cy* in order to avoid undesirable stress assignment as shown in (7).

(7) Pattern 2 (LĹX) and 4 (HĹX)
FT-BIN, NON-FIN, PARSE, TROCHEE » ALI-F-R

INPUT	Candidates	Optimal Output	CONSTRAINTS				
			FT-BIN	NON-FIN	PARSE	TROCHEE	ALI-F-R
efficient	(effí)<cient>	1				1	2
	effí<cient>				2		
	[(e)(ffí)]<cient>		2			1	3
	(effí)(cient)	1		1			2
	(e)[(ffí)(cien)]<cy>		1				6
lieuténant	(lieuté)<nant>		1			1	3
	lieuté<nant>				2		
	[(lieu)(té)]<nant>	1	1			1	1
	lieu[(té)(nant)]	1	1	1			1
	(lieu)[(té)(nant)]<cy>		1				6

4. Empirical Data

Then, how similar or different are the results of the analysis from English speakers' intuition? In addition to providing phonological analysis of actual data, it is of great importance to investigate how well the analysis fits with novel words. In this section, we explore English speakers' performance with respect to English noun allomorphy along with stress assignment.

In order to verify the phonological analysis with nonce words, we conducted a survey with English non-words. The survey was performed on paper by 9 native speakers of English who voluntarily participated. The participants were all recruited around the University of Michigan, Ann Arbor campus. They were instructed to choose the most natural noun endings for each given adjective form.

The nonce words included in the survey were constructed to be consistent with English phonotactics and to maximally correspond to real words in terms of syllable structures, weight and stress assignment. The

actual format of the survey is provided in (8). Since Pattern 6 and 8 are not attested in real English words, the two patterns were not included in the survey. Only six patterns that actually appear in English were included. There were 19 nonce words and each of them followed one of the six patterns. The words were randomized in order when they were presented to the participants.

(8) Survey format

> [Survey] **Allomorph selection: the case of *-ce* and *-cy***
> The followings are non-words in English. The left column − the adjectiveforms − is the base. The stress of each base is marked on the adjectives. Please choose a noun suffix which you think might be appropriate.
>
> 1. lógatant *-ce* ( ) *-cy* ( )
> 2. tándipent *-ce* ( ) *-cy* ( )

The 19 words are provided in the following table, in which the English non-words were organized into six patterns.

(9) Words in patterns

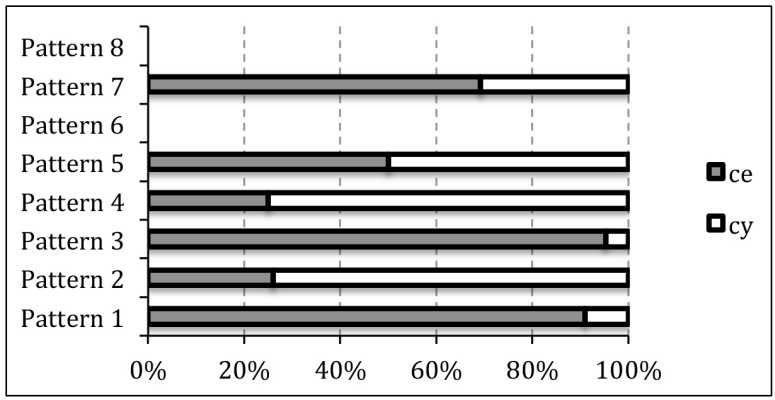
Pattern	Expected	English nonce words
1 Ĺ L X	*-ce*	*lógatant, démolant, thémobent*
2 L Ĺ X	*-cy*	*dinérent, benátent, kaefévent*
3 Ĥ L X	*-ce*	*tándipent, dílxobant, térvefent, sídgafant, néikoment, lóubement*
4 H Ĺ X	*-cy*	*kaplúment, anrévent*
5 L Ĥ X	*-ce*	*gedóulent, sudólgent, trekénvent, chogésbant*
7 H Ĥ X	*-ce*	*wonméelant*[1)]

1) It was found that when heavy penult syllables were presented with vowels as in *-ee*, *-ea*, participants possibly interpreted them as lax so that some of HHX expected words *wonméelant* might be actually understood as HLX. In order to avoid the possibility, some words were tested separately. In the words containing a consonant in the coda

As shown above, a stress marker for each item is placed on the base adjective form. Every non-word falls onto one of the six stress patterns. The number of nonce words was not evenly distributed to roughly reflect the frequency of each pattern; for instance, the frequency of Pattern 4 is relatively low and that of Pattern 2 is high, so this was represented in the number of nonce words.

Based on the previous theoretic analysis of English stress rules, the choice of *-cy* is expected for Pattern 2 and 4. The rest of the patterns that accord English stress rules prefer *-ce* as the appropriate English noun allomorph. The result of the mini-survey is provided in (10).

(10) Figure: English speakers' responses for English noun allomorphy



The figure above demonstrates the native speakers' responses regarding English allomorph selection. In the figure, the x-axis shows the percentage of choice *-ce* (i.e., the black bar in the figure) or *-cy* (i.e., the white bar). The y-axis indicates six different kinds of patterns. Patterns 1, 3, 5 and 7 that generally obey general English stress assignment rules were expected to adopt *-ce* as in the previous phonological analysis. According to the result of the survey, more than 50% of the responses of Pattern 1, 3 and 7 favored *-ce* over *-cy*, while the *-ce* responses in Pattern 5 was only around 50%. It can be arguably suggested that *-ce* ending is selected for

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such as *conméslant* and *compéalent*, it was ensured that the penultimate syllable was heavy. The results of this test were consistent with the survey.

these patterns. That is, when the adjective bases contain appropriate stress patterns that conform general English stress rules, the bases preserves the *optimal* stress patterns. The degree of favoring *-ce* varies among the patterns, which corresponds to the corpus results of English real words (author's previous work). In the corpus data, Pattern 3 (H́LX) did not have any counter-examples, while some of Pattern 5 (LH́X) adjectives chose *-cy* ending.

On the other hand, Pattern 2 and 4, which were discussed as having a *less optimal* stress assignment in the previous section, were expected to select the *-cy* ending. In this figure, the percent of *-ce* was less than 30% in both Pattern 2 and 4. That is, in most of the cases, English speakers were in favor of *-cy* when the prosodic structure of the base does not comply with the general stress placement rules. This can be interpreted as English speakers' strategy to resolve a *less optimal* stress assignment by extending the length of the syllable.

In summary, the result of the survey indicates that the allomorph selection correlates with the previously suggested phonological analysis. English speakers showed a strong bias toward the *-ce* ending when the prosodic structure follows that of Pattern 1 (ĹLX), 3 (H́LX), 5 (LH́X) or 7 (HH́X). However, they alternatively prefer the *-cy* ending when the structure is either Pattern 2 (LĹX) or 4 (HĹX). The contrasting preference for English *-ce*/*-cy* noun allomorphs may be in part explained by the prosodic structures of the bases and by stress patterns in particular. Also, the phonological account of the Optimality Theoretic approach appears to coincide with the empirical survey data reflected by English speakers' intuition.

5. Conclusion

In this morphophonological research, we examined the selectional properties of English noun allomorphy in terms of prosodic/phonological investigation: the prosodic structures along with stress assignment determine the allomorph. It was proposed that English allomorph selection of *-ce*

and *-cy* is phonologically conditioned such that *-ce* is adopted when the prosodic structure of the base conforms to general English stress assignment rules, whereas *-cy* is selected when the structure requires syllabic modification. The phonological analysis was examined with Optimality Theoretic accounts. I argued that the analysis has to be verified with empirical data, and provided a survey result with nonce words that complies with the suggested phonological analysis. Through the results of the small-scale survey, it was suggested that the allomorph selection has a strong correlation with general English rules.

It is possible that some of the nonce words incorporated in the survey could have been understood differently from the tester's intention. For instance, English has a phonological process called Open Syllable Lengthening. It refers to a phenomenon that English speakers lengthen the vowel duration when the syllable is open. By extending the vowel length, a lax short vowel may be converted into a tense long one. This issue is likely to be solved by incorporating a listening task or be designing a production experiment. These studies are planned for the next step of the investigation. Also, participants' responses for Pattern 5 were only chance level, which certainly should be investigated further.

Regardless of the limitations, it is obvious that a theory should be supported by concrete data and that when the existing data are explained by 'rules', then the rule should be applied productively to novel forms – theories cannot stand alone without sufficient data. Theoretical accounts, empirical corpus data and experimental applications should be considered at the same time for better understanding of human language processing.

In this sense, along with quantitative or experimental studies, it is suggested that phonotactic learner simulations be added to the analysis. In Gouskova and Newlin-Lukowicz (under review), the ULCA Phonotactic Learner (Hayes & Wilson 2008), a computational implementation of a probabilistic learning model, was suggested to examine the phonotactic grammar of affixes. They trained the learner and tested the grammar of given stimuli. The simulation of the learner partly mirrored people's rating of the same stimuli and successfully found the phonological generalization

regarding allomorph selection. This learning simulation can be applied to examine English allomorph selection, which is the best method for a follow-up study.

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