Experimental Exploration of Ambisyllabicity in English

by

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Abstract

Some theories of the syllable predict that single intervocalic consonants will be ambisyllabic (acting simultaneously as the coda of one syllable and onset of another syllable) in certain contexts. However, these predictions are not borne out in experimental data. Previous research has found that ambisyllabicity occurs in some theoretically predicted contexts, but not others. This research looks at whether syllable onsets can be used to predict ambisyllabicity in an experimental setting. With recent research suggesting that onsets may contribute to syllable weight, it is expected that variability in onset type will affect syllabification of intervocalic consonants, which is largely dependent on the weight of the preceding syllable. Participants performed a syllable reversal task in response to bisyllabic non-words. Non-word stimuli were used to control for the effects of orthography, morphology and frequency. Results from the first experiment, in which all stimuli had tense vowels, showed that the occurrence of ambisyllabicity was low overall, but was proportionally more frequent in response to stimuli with fewer onset consonants, and vice versa. In order to investigate this further, a second experiment was conducted using stimuli with both tense and lax vowels. Results from the second experiment showed the same trends for stimuli with lax vowels only. As ambisyllabicity is expected to occur in contexts where syllables require codas for additional weight, the results suggest that onsets can also contribute to syllable weight. In both experiments, the occurrence of ambisyllabic responses was much lower than expected based on similar research that used real-word stimuli. This indicates that the use of non-words affected participants’ syllabification judgements and demonstrates the important role of lexical effects in phonological tasks.

Keywords: ambisyllabicity; psycholinguistics; syllable structure; onsets and syllable weight; non-words;
Dedication

To my Dad
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Chapter 1.

Introduction

1.1. Goals

In this thesis, I relate a theoretical account of English syllables with experimental facts about speakers’ understanding and use of syllables. In particular, I focus on ambisyllabicity and what factors may bring it about. Ambisyllabicity occurs when a single intervocalic consonant acts as the coda to a preceding syllable, while simultaneously acting as the onset of the following syllable.

Figure 1.1  Ambisyllabic consonant in ‘raccoon’

Ambisyllabicity is an interesting assertion about English syllables because it is motivated by theoretical principles that are widely accepted. According to the Onset Principle, a vowel that follows a single intervocalic consonant requires an onset in order to construct a well-formed syllable. When the vowel preceding the same single intervocalic consonant requires a coda, ambisyllabicity is expected to occur. There are two principles that require a syllable to have a coda consonant: the Stress Principle, which states that stressed syllables attract consonants, and Lax Vowel Closing, which
states that lax vowels cannot be in open syllables. Both of these principles are motivated by the need to increase syllable weight.

Ambisyllabicity allows a single consonant to occupy two structural positions, simultaneously satisfying the requirements of the syllable it precedes and the syllable it follows. While this seems like a reasonable theoretical account, it is not borne out in experimental research. Experimental results do show, as phonological theory would predict, that ambisyllabicity is more frequent when the syllable preceding the intervocalic consonant is stressed and is also more frequent when there is a lax vowel preceding the intervocalic consonant. However, speakers do not provide ambisyllabic responses in all theoretically expected contexts, and while ambisyllabicity is more frequent in the phonological contexts in which it is expected to occur, it is not the preferred syllabification strategy in these contexts, or any other phonological context.

This research will elicit and analyze ambisyllabic responses in an attempt to better characterize their occurrence. It will examine how ambisyllabicity is affected when certain variables are manipulated, controlling for variables that have known effects and considering variables that have not yet been investigated. The goal of probing such factors is to arrive at an analysis of English syllables that unifies theoretical insights with experimental facts.

1.2. Motivation

Previous research has shown that a number of non-phonological factors can affect speakers’ behaviour in syllabification tasks. Speakers are more likely to provide an ambisyllabic response to a word if the orthographic representation includes two consonants e.g. ‘puppy’, ‘pillow’ compared to a word with one consonant in orthography e.g. ‘peanut’, ‘punish’ (Treiman & Danis, 1988). Even in an oral task, speakers ambisyllabify single intervocalic consonants up to 80% of the time when the stimuli are spelled with two consonants, compared to 23% of the time when stimuli are spelled with one consonant (Treiman & Danis, 1988). Eddington, Treiman, and Elzinga (2013) found that morphology may also affect syllabification. They demonstrated that intervocalic consonants are more likely to be syllabified as onsets when they follow a morpheme
boundary, even if the morpheme boundary is opaque i.e. no relationship exists between the base and the affixed form. Cholin, Levelt, and Schiller (2006) reported syllable frequency effects in speech production tasks, though not specifically in syllabification tasks. These findings, though important, do not reveal anything about the phonological motivation for ambisyllabicity. In fact, some of these non-phonological effects are so strong that they are likely obscuring effects of phonological factors. This research aims to reduce the effects of orthography, morphology, and frequency so that phonological motivations for ambisyllabicity become more clear. This will be done by administering a syllabification task that uses non-word stimuli. Phonological factors that have previously been shown to affect syllabification such as vowel type, stress placement, intervocalic consonant type, and syllable frequency, will also be controlled in this experiment.

The phonological advantage of ambisyllabic consonants is that in addition to satisfying the Onset Requirement of a following syllable, they can also increase the weight of a syllable that precedes them. As such, the likelihood that a consonant be treated as ambisyllabic is strongly related the phonological qualities of that syllable that precedes it. Vowel quality and stress placement have both been shown to affect the syllabification of a following intervocalic consonant. However, something that has not yet been considered is how the onset of the syllable affects ambisyllabicity. This is likely because phonological theory generally assumes that onsets do not contribute to syllable weight (Hyman, 1984). Recent research has provided opposing evidence suggesting that onset types do in fact contribute to syllable weight, and that onsets with more consonants contribute more weight (Kelly, 2004; Ryan, 2014). If this is the case, variation in syllable onsets is also expected to affect syllabification, and syllabification tasks should be revisited with this expectation in mind.

Though it is not often assumed in English, it is claimed in a number of other languages that a null onset is lighter than a filled onset. Evidence from onset-sensitive stress systems in Western Aranda (Davis, 1988), Pirahã (Gordon, 2005; Topintzi, 2008) and various other languages have been used to support this claim. Kelly (2004) performed a statistical analysis of a corpus of bisyllabic English words and found that the number of consonants in the initial onset is correlated with the propensity for primary stress. Ryan (2014) extended this analysis, showing that the correlation holds when
syllables are not word-initial. In order to probe this further, an experiment was conducted in which English speakers were instructed to assign stress to non-word stimuli. The speakers were more likely to stress the initial syllable as the number of onset consonants increased (Kelly, 2004; Ryan, 2014), indicating that the effect is more than a statistical observation about English, rather that speakers are sensitive to these finer weight distinctions. According to the Weight-to-Stress Principle heavy syllables should be stressed (Prince, 1990), therefore demonstrating that an increase in the number of onset consonants correlates with an increased propensity for stress can be interpreted as evidence that onsets contribute to syllable weight. The possibility that onsets contribute additional weight is important for ambisyllabic, because ambisyllabic is motivated entirely by a syllable’s need to increase its weight. If an increase in the number of onset consonants correlates with an increased occurrence of stress, it may also correlate with decreased occurrence of ambisyllabic, because contrary to stress, a phenomenon that occurs specifically where there is a heavy syllable, ambisyllabic occurs where a syllable needs to increase weight.

1.3. Synopsis

This research used an oral syllable reversal task to investigate the syllabification judgements of English speakers, who were given non-word stimuli. Results showed that the percentage of ambisyllabic responses was greater in response to onsetless stimuli and stimuli with singleton onsets, compared to cluster onsets.

It was also found that in all contexts, ambisyllabic responses were highly dispreferred. Responses where participants syllabify intervocalic consonants as codas were also dispreferred. Participants preferred to syllabify single intervocalic consonants as onsets in all contexts.

These findings and the relevant background information will be presented according to the following structure:

Sections 2.1 and 2.2 will introduce a definition of the syllable and the subsyllabic constituents. The Sonority Sequencing Generalization will be discussed and a syllable
template will be used to illustrate its effect on syllable structure and syllables that are permitted in English.

In Section 2.3, syllabification will be discussed. Segments are assigned to structural positions within a syllable according to a number of theoretical principles which are laid out in this chapter. Theoretical evidence to support these principles will be presented. A number of contexts where theoretical principles may predict conflicting outcomes will also be identified.

In Section 2.4, ambisyllabicity will be discussed. Ambisyllabicity is proposed in some theories to account for conflicting principles of syllabification. However, not all theories allow for ambisyllabic consonants. Theoretical evidence to support ambisyllabicity will be presented. Alternative accounts will also be presented.

In Section 2.5 experimental evidence will be discussed. This will begin with an overview of several experimental methods commonly used to investigate syllabification. The remainder of the chapter will present experimental evidence supporting the numerous principles introduced in Section 2.3.

In Chapter 3 the experimental design will be presented. Methodology, stimuli design and participants will be discussed. Results from the pilot study will also be presented. This discussion leads up to the first experiment. The first experiment was a syllable reversal task using non-word stimuli, in which the vowels were restricted only to tense vowels. Results from the first experiment, including analysis and discussion will be presented in this chapter.

Chapter 4 will discuss the second experiment, which was another syllable reversal task using composed non-word stimuli with either tense or lax vowels. Methodology and participants remain largely unchanged. However, changes to the stimuli and motivation for these changes will be explained. Results from the second experiment, including analysis and discussion will be presented.
Chapter 5 will provide a general discussion of the results. Conclusions and implications for phonological theory will be discussed. Areas for further research will be identified.
Chapter 2.

The Syllable in Phonological Theory

This chapter will provide a theoretical account of the syllable in English, first introducing the constituent parts of the syllable and describing how they fit together. Next, it will provide a template to capture the hierarchical structure of the syllable, and the theoretical principles that determine how segments are assigned to structural positions. Experimental evidence to support these tenets will also be discussed.

2.1. Overview

The syllable is an organizational unit in the structure of a word. The syllable itself has an internal structure, made up of subsyllabic constituents, which are in turn composed of one or more segments. The nucleus is the only obligatory segment, and as the most sonorous segment in the syllable, is usually a vowel. The coda is the consonant or sequence of consonants following the vowel. Together, the nucleus and coda make up the rhyme (sometimes written as ‘rime’). The consonant or sequence of consonants that precede the rhyme is called the onset.

Figure 2.1   Syllabification of the word ‘cat’
Note: Sy = Syllable, On = Onset, Rh = Rhyme (or Rime), Pe = Peak (or Nucleus), Co = Coda
In English, both onsets and codas are optional, and may have either one or two consonants. For example, words such as ‘amber’ and ‘impact’ begin with the onsetless syllables ‘æm’ and /ɪm/, while the words ‘jelly’ and ‘canoe’ end with vowels /i/ and /u/ respectively, which are not followed by codas. Any monosyllabic word beginning with a single consonant e.g. ‘late’, ‘ray’, ‘rip’ is an example of a syllable with single consonant as an onset. The existence of monosyllabic words such as ‘plate’, ‘pray’ and ‘trip’, with an additional consonant in the onset, illustrate that syllables with two consonants in their onset are also permitted if the cluster includes an obstruent followed by a sonorant. Any monosyllabic word ending with a single consonant e.g. ‘tar’, ‘hall’, and ‘sick’ is an example of a syllable with a single consonant coda. Monosyllabic words ‘tart’, ‘halt’ and ‘sink’ have an additional consonant in the coda, thus illustrating that syllables with two consonants in the coda are also permitted.

2.2. The Syllable Template

Syllable templates may vary with respect to detail and complexity. Simple templates propose a sequence of CV units, while more advanced templates include the structural nodes of onset, nucleus and rhyme which are filled with segments. The Moraic Hypothesis (Hyman, 1985) argues that segmental units are underspecified, and claims that syllables are comprised of prosodic units called moras. Moras can be described as a unit of syllable weight, making this analysis useful in describing weight-based phenomena like stress assignment. However, not all segments contain moras, and mora counts may differ across theories. As such, a template using only moras does not provide a complete description of the syllable.

Giegerich (1992) proposes a detailed template of the English syllable, which lays out all of its structural positions. While the template does not explicitly use the mora as a prosodic unit, it does capture the fact that segments may vary with respect to weight, and the condition that some segments contribute weight when they occupy certain structural positions e.g. coda position, but not others e.g. onset position. It also includes featural restrictions with regards to which segment (or groups of segments) can occupy each structural position. These generalizations are built into the template itself.
Figure 2.2. Syllable Template

Sy = Syllable, On = Onset, Rh = Rhyme (or Rime), Pe = Peak (or Nucleus), Co = Coda

In this template, segments are represented as bundles of features, and these bundles are to be associated with X-positions. The X-positions are associated with the higher order units Onset, Rhyme, Peak (or Nucleus) and Coda. Only X1 and X>1 are obligatory, which implies that onsets are optional and that the Peak must be made up of two X-positions. This requirement can be satisfied in two ways: either the Peak has a tense vowel, which occupies two X-positions (X1 and X2) or the peak has a lax vowel occupying X1, a coda consonant occupying X2.

In order to fill the template, segments within a word must be associated with structural positions in the template. Itô (1986) claims that this is done with skeletal insertion rules and a template matching algorithm, which will scan segmental strings and assign segments to structural positions based on the insertion rules. Itô (1989) provides evidence from epenthesis to support this idea over rule-based approaches. Not all theories make specific reference to the mechanism that associates segments to structural positions, though every theory must include principles that determine which segments are permitted in which positions.
2.3. Theoretical Principles

2.3.1. The Sonority Sequencing Generalization

Many of the restrictions laid out in the Giegerich (1992) template are based on the Sonority Sequencing Generalization:

Between any member of a syllable and the syllable peak, a sonority rise must occur. (Clements, 1990; Selkirk, 1982)

The generalization in 1) requires that all syllables rise in sonority towards the peak and fall in sonority after the peak. Segments in an onset must therefore be ordered from least sonorous to most sonorous and segments in a coda must be ordered from most sonorous to least sonorous, with the sonority of segments defined on a sonority scale that is specific to each language. Additionally, adjacent onset segments must be separated by a minimal difference in sonority.

Table 2.1. The Sonority Scale

<table>
<thead>
<tr>
<th>Oral Stops</th>
<th>Fricatives</th>
<th>Nasals</th>
<th>Liquids</th>
<th>Semivowels</th>
<th>Vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voiceless</td>
<td>Voiced</td>
<td>Voiceless</td>
<td>Voiceless</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>p</td>
<td>b</td>
<td>f</td>
<td>v</td>
<td>m</td>
<td></td>
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<td>t</td>
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<tr>
<td>k</td>
<td>g</td>
<td>s</td>
<td>z</td>
<td>η</td>
<td>l</td>
</tr>
</tbody>
</table>


Differences in minimal sonority distance requirements, as well as differing sonority scales across languages, can account for the fact that certain onsets may be permissible in one language but not another (Steriade, 1982). In Russian, for example, onset clusters such as ‘vd’ in the word ‘vdova’ (‘widow’) are permitted because there is no sonority distinction between fricatives and stops. In English, a fricative followed by a stop would create a fall in sonority, therefore these sequences are not permitted. In
order for onset clusters to satisfy minimal sonority distance requirements in English, the second consonant must be a sonorant. Post-vocalically, segments closer in sonority value are tolerated (Blevins & Goldsmith, 1995): as long as the first segment of a coda cluster is more sonorous than the second segment, a coda will be well-formed.

Giegerich (1992) points out that many monosyllabic words may contradict these generalizations. Initial s-clusters, such as /spr/ in ‘spring’, have more than two consonants, and in addition, these clusters violate the Sonority Sequencing Generalization, as /s/ is more sonorous than /p/. Similarly, final s-clusters, such as /mps/ in ‘clamps’, also have more than two consonants and violate the Sonority Sequencing Generalization as well. Segments that violate these generalizations are called appendices: they are not subject to sonority requirements because they are not part of the core onset or coda. A well-formed onset may be preceded by an appendix /s/ and well-formed coda may be followed by up to three appendices, which must be coronal obstruents.

2.3.2. The Onset Principle

The Sonority Sequencing Generalization is used to account for syllable-internal structure. Restrictions on syllable internal structure affect the way segments become affiliated with structural positions, because first and foremost, violations of the Sonority Sequencing Generalization must be avoided. In some cases, the Sonority Sequencing Generalization allows for more than one possible syllabification. For example, given the word ‘pontoon’ syllabification as either ‘pont.oon’ or ‘pon.toon’ both adhere to the Sonority Sequencing Generalization. In these cases, further principles must be applied to resolve the ambiguity. One such principle is the Onset Principle, which states that all syllables must have onsets. This principle is widely accepted and may be referred to as the Onset Principle (Itô, 1989), or the CV rule, referring to the fact that VCV sequences are syllabified as V.CV rather than VC.V (Clements & Keyser, 1983). Giegerich (1992) calls this the Syllable Boundary Rule:
Syllable Boundary Rule – Within words, syllable-boundaries are placed in such a way that onsets are maximal (in accordance with the phonotactic constraints of the language)

Itô (1989) achieves the same effect with a rule that avoids onsetless syllables, seen in 2). In generative phonology, the Onset Principle can be expressed as a constraint against onsetless syllables, as seen in 3). In English, this constraint is violable, which makes it similar to the rule proposed by Itô (1989), effectively stating that onsetless syllables are to be avoided in English.

Avoid σ[V (Itô, 1989)

or

Syllables must have onsets (Prince, Smolensky, & Prince, 1993)

2.3.3. Lax Vowel Closing

While the onset principle necessitates that syllables have onsets, lax vowel closing necessitates that some syllables have codas.

Lax vowel closing – lax vowels must be in closed syllables

Many theories stipulate that consonant sequences that are illegal word-initially or word-finally are illegal syllable-initially or syllable-finally respectively (Kahn, 1976; Pulgram, 1970). The observation that lax vowels do not occur word-finally in English can be extended to disallow lax vowels in syllable final position. Therefore, lax vowels must always be followed by a coda (Hammond, 1999; Pulgram, 1970). In order to account for lax vowel closing, Hammond (1999) proposes a bimoraicity constraint, requiring that all syllables are minimally bimoraic:

Bimoraicity – All syllables must be bimoraic (Hammond, 1999)

This constraint is also established in the Giegerich template. The template requires that the Peak be made up of two X-positions, which corresponds to two moras.
Because a lax vowel contributes only one mora, this constraint requires that lax vowels are followed by a moraic coda consonant. In the context where a single intervocalic consonant could affiliate either as a coda or an onset, a conflict will between these two principles.

2.3.4. The Stress Principle

The Stress Principle can also cause syllables to attract consonants in to coda position in certain contexts.

The Stress Principle - stressed syllables attract consonants (Bailey, 1978; Kahn, 1976)

If the syllable preceding an intervocalic consonant is stressed, the consonant will be attracted to the coda position. This principle motivated by the fact that in English, stressed syllables are usually heavy. Some theories include constraints that cause stressed syllables to be heavy (Giegerich, 1992; Pulgram, 1970), whereas conversely, some theories include constraints stipulating that polymoraic or heavy syllables must be stressed (Hammond, 1999; Prince, 1990). Prince (1990) points out that the observation that heavy syllables attract stress, does not imply that stressed syllables must be heavy. However, he acknowledges that “stressed syllables are not infrequently made heavy in the course of phonological derivation” (p.4). Because syllables with tense vowels already meet minimum weight requirements i.e. have two moras, some linguists claim that only stressed syllables with lax vowels attract coda consonants (Giegerich, 1992; Pulgram, 1970). For other linguists this is a more general property of syllabification (Bailey, 1978; Kahn, 1976).

2.4. Ambisyllabicity

Using the principles presented above, theories make predictions about how intervocalic consonants will be syllabified. Some principles require syllable codas, whereas others require syllable onsets. In a word with an intervocalic cluster, the cluster can often be broken up to satisfy both structural requirements; when only one
intervocalic consonant is available the solution is less straightforward. If a single intervocalic consonant is preceded by a syllable that requires a coda consonant, this requirement cannot be satisfied unless the onset principle is ignored. There are differing hypotheses as to how this might be resolved. Selkirk (1982) and Borowsky (1986) propose a resyllabification theory, where syllabification occurs in two stages. First, syllabification occurs according to the onset principle, ensuring that all syllables have an underlying structure of CV, which she refers to as the Basic Syllable Composition. Divergences from Basic Syllable Composition may only occur in definable contexts, specifically when a single intervocalic consonant precedes a stressless vowel. In these contexts, the intervocalic consonant is first syllabified as the onset of the following syllable and then resyllabified as the coda of the preceding syllable. She describes this as a ‘complete dissociation of the consonant from the syllable origin’ (Selkirk, 1982, p.361). Therefore, in surface form, single intervocalic consonants are syllabified as codas. Because theories of resyllabification propose two levels of syllabification, and it is not clear what stage will be accessed in syllabification tasks, resyllabification does not make explicit predictions about how speakers will syllabify single intervocalic consonants experimentally.

The second way this conflict can be resolved is with an ambisyllabic consonant, which is a single intervocalic consonant that occupies two structural positions within two separate syllables. There is phonetic and experimental evidence that suggests that a consonant may be treated differently if it is the single consonant between two vowels. In many dialects of English, including America English, pre-vocalic /l/ is phonetically distinct from post-vocalic /l/. The prevocalic allophone referred to as clear /l/ is non-velarized, whereas the post-vocalic allophone referred to as dark /l/ is velarized. Lehiste (1964) and Bladon and Al-Bamerni (1976) both found that intervocalic /l/ is intermediate in quality, suggesting that an ambisyllabic variant exists and that it is phonetically distinct.

Stemberger (1983) provides further evidence that /l/, as well as /r/, behave interestingly in intervocalic position. Using a corpus of natural speech error data, he looks at exchange errors, in which one segment is replaced with another segment from the word. For example:
reek long race – week long race /r/ from ‘race’ is incorrectly produced in place of the /w/ from ‘week’ (Fromkin, 1971)

John gave the goy – John gave the goy /g/ from ‘gave’ is incorrectly produced in place of the /b/ from ‘boy’ (Fromkin, 1971)

Stemberger (1983) notes that it is rare for segments in different syllabic positions to interact (Fromkin, 1971). Errors in which pre-vocalic and post-vocalic segments interact are infrequent. However, in his corpus, there were numerous examples where intervocalic /l/ and /r/ interact with both pre-vocalic and post-vocalic segments. For example:

licitate – dictate policies intervocalic /l/ from ‘policies’ exchanges with pre-vocalic /d/ from ‘dictate’ (Stemberger, 1983)

eucalypt – eucalypt intervocalic /l/ from ‘eucalypt’ is exchange with the postvocalic /p/ from ‘eucalypt’ (Stemberger, 1983)

These findings provide interesting insight into speakers’ subconscious understanding of the syllable. Further empirical evidence can be obtained by eliciting speakers’ syllabification judgements in an experimental setting.

2.5. Experimental Evidence

Thus far, a theoretical analysis of syllabification has not reached a consensus concerning ambisyllabicity and the syllabification of single intervocalic consonants. Experimental evidence is often been cited in support of the theoretical principles laid out in the previous chapter. Further experimentation may also provide insight as to whether ambisyllabicity is a valid syllabification, and how it is used.

2.5.1. Investigating Syllabification Experimentally

There are numerous experimental tasks that can be used to investigate syllabification, depending on the goals of the experiment. Côté and Kharlamov (2011)
summarize the types of tasks that are typically used to investigate syllabification judgements and highlight the advantages and disadvantages of each. These tasks include syllable reversal, syllable reduplication, syllable repetition, syllable substitution, pause insertion, and fragment insertion. Most of these tasks may be administered either orally or in written form. Speakers may be asked to syllabify stimuli themselves, which may yield a greater variety of response types, or they may be asked to choose their preferred syllabification given several options.

In syllable reduplication tasks, replication tasks, and substitution tasks, ambisyllabic responses are not possible. In a syllable reduplication task participants are asked to reduplicate a syllable in the stimuli. For example, a bisyllabic word like ‘demon’ may become ‘de-demon’ or ‘dem-demon’, depending on how the participant has affiliated the medial consonant. In a syllable repetition task, participants are asked to repeat a syllable in the stimuli. For example, participants may be asked to repeat only the first syllable in a bisyllabic word like ‘demon’ and may respond with ‘de’ or ‘dem’ depending on how the participant has affiliated the medial consonant. The problem with these tasks is that they do not provide enough information to determine whether a participant has provided an ambisyllabic response. If a participant is given the word ‘demon’ and produces ‘dem-demon’ in a reduplication task, (or ‘dem’ in a repetition task) it cannot be determined if /m/ has been syllabified as only the coda of S1, or both the coda and onset. As such, this task is not suitable for investigating ambisyllabicility.

Syllable substitution tasks, though different, are subject to the same issue. In a substitution task, participants are asked to replace one of the syllables in the stimulus with a specified sequence. For example, Bertinetto, Caboara, Gaeta, and Agonigi (1994) asked participants to replace a syllable with the sequence /vu/. A bisyllabic word like ‘demon’ may become ‘vumon’ or ‘devu’. Again, if a participant is given the word ‘demon’ and responds with ‘vumon’ it cannot be determined whether the /m/ has been syllabified as the coda of S1, or as both the coda of S1 and onset of S2.

In pause insertion tasks, fragment insertion tasks and syllable reversal tasks, ambisyllabic responses are possible. In a pause insertion task participants are asked to insert a pause between syllables in the stimuli. For example, a bisyllabic word like
‘demon’ may become ‘de…mon’ or ‘dem…on’. A fragment insertion task is similar to a pause insertion task but instead of inserting a pause, participants insert additional material before or between syllables. For example, given the bisyllabic word ‘demon’, participants may produce ‘I say de then mon’, inserting material before the first syllable and between the two syllables (Côté & Kharlamov, 2011). Both tasks allow for ambisyllabic responses. If a participant were given the word ‘demon’, the response ‘dem…mon’ would be considered ambisyllabic.

In syllable reversal tasks, participants are asked to reverse the order of syllables in the stimuli. For example, a bisyllabic word like ‘demon’ may become ‘mon.de’, ‘on.dem’ or ‘mon.dem’, depending on how the participant has affiliated the medial consonant. This task is used by Treiman and Danis (1988) to investigate English syllabification. It was subsequently used in numerous other studies to investigate syllabification in other languages, including Content, Meunier, Kearns, and Frauenfelder (2001) in French, Schiller, Meyer, and Levelt (1997) in Dutch, and Barry, Klein, and Köser (1999) in German. In each of these studies participants provided ambisyllabic responses.

A syllable reversal task was selected for this experiment because it is best suited to investigate ambisyllabicity. This is not to say that other methods are not valid, simply that they are not adequate for this research. As noted above, the syllabification principles laid out in the previous chapter have been investigated using a variety of methodologies. Section 2.3.2 will provide some examples of this research.

2.5.2. The Onset Principle

There is significant experimental evidence supporting the validity of the Onset Principle. Treiman and Zukowski (1990) used a written syllabification task in which participants were presented with oral stimuli, and asked to choose a preferred syllabification from a written answer sheet. They found that even if a consonant cluster is legal word finally, it is still significantly more likely to be separated word medially than to syllabify as a coda e.g. pon.toon is more likely than pont.oon. In contrast, they found that consonant clusters that are legal word initially generally appear in the onset of a syllable
word-internally e.g. me.tr.o is more likely than met.ro, and that these findings hold regardless of stress placement. This indicates a preference for syllables to maximize onsets. Redford and Randall (2005) replicated these findings in a modified version of the slash-insertion task, which included stimuli with phonetic variability. Participants were asked to listen to a word orally then write it down inserting a slash where they would split the word. The stimuli were produced by four different speakers, which yielded variation in consonant and vowel. They found that the preference for pon.toon over pont.oon is highly significant, regardless of phonetic variability. Ishikawa (2002) investigated the way intervocalic consonants were syllabified in English words and non-words, using an oral pause insertion task. In this experiment, the participants asked to choose a preferred syllabification. It was found that both English and Japanese speakers chose CV.CVC syllabification more frequently than CVC.VC or CVC.CVC syllabification, again providing support for the Onset Principle.

2.5.3. Lax Vowel Closing

The prediction that lax vowels must be followed by coda consonants is also supported experimentally. In a syllable reversal task, where speakers were asked to syllabify English words, Treiman and Danis (1988) found that speakers are more likely to syllabify in a manner that does not leave a lax vowel in an open syllable, which can only be achieved by having a coda consonant following the lax vowel. When given a bisyllabic word with a lax V1 and a single intervocalic consonant, speakers syllabified the critical consonant as the onset of S2 in 33% and 29% of responses when the critical consonant was a liquid or nasal respectively. This demonstrates that when the critical consonant was a liquid or nasal, speakers prefer to either ambisyllabify the consonant, or syllabify the consonant as the coda of S1. Both of these response types avoid syllabifying lax vowels in open syllables. When the V1 was tense, speakers syllabified the critical consonant in the onset of S2 in 58% and 68% of responses when the critical consonant was a liquid or nasal respectively. Therefore, the preference for closed syllables is stronger when V1 is lax. Presumably, this is because speakers avoid syllabifying lax vowels in open syllables, whereas tense vowels are permitted in open syllables. Another strategy was for speakers to lengthen the lax vowel rather than closing the syllable with a coda (Schiller et al., 1997).
2.5.4. The Stress Principle

There is also experimental evidence to support the claim that stressed syllables attract consonants. Treiman and Zukowski (1990) found that cases where participants syllabified VCC.V (over VC.CV) were significantly more frequent when S1 is stressed as opposed to S2. Eddington et al. (2013) also found an effect of primary stress when participants were asked to choose their preferred syllabification of an English word presented in written form, with quasi-phonemic transcriptions. They found that that stressed initial syllables favour C while stressed final syllables favour .C, which is consistent with the claim that consonants are drawn into stressed syllables. Redford and Randall (2005), investigated the effects of phonetic variables on syllabification and found that V1 vowel length was a significant predictor of syllabification, specifically that longer V1 duration was associated with VC.CV syllabification and shorter V1 duration was associated with V.CCV syllabification. Effectively, longer duration in V1 attracts consonants. Because stress is generally associated with longer vowel duration, these results also support the claim that stressed vowels attract consonants. From an articulatory perspective, Krakow (1989) and Turk (1994) both found that physiologically, intervocalic consonants exhibit more articulatory properties of codas when preceded by stressed vowels, and exhibit more articulatory properties of onsets when followed by stressed vowels.

2.5.5. Intervocalic Consonant Type

In addition to the theory-based principles that were investigated, experimental evidence also suggests that liquids and nasals cohere with vowels to a greater degree than obstruents. Yavaş and Gogate (1999) found that children are able to segment less sonorant coda consonants more easily than sonorant ones, demonstrating that sonority plays a role in the development of phoneme awareness. Assuming sonorants are more closely affiliated with preceding vowels than obstruents, it is predicted that intervocalic sonorants are more likely to be syllabified in coda position than obstruents. A variety of experimental tasks provide evidence to support this. Ishikawa (2002) used an oral pause insertion task with English words and non-words, where participants were asked to choose their preferred syllabification. He found that both English and Japanese speakers
preferred syllabifications with intervocalic consonants in coda position if the consonant was a sonorant. Treiman and Danis (1988) found that syllabifying consonants in coda positions was most common when the intervocalic was a liquid, slightly less common when the intervocalic consonant was a nasal and least likely when the intervocalic consonant was an obstruent. Additionally, ambisyllabifying consonants was most common when the intervocalic was a liquid, slightly less common when the intervocalic consonant was a nasal and least likely when the intervocalic consonant was an obstruent. This effect has also been found in other languages such as French (Content et al., 2001) and Korean (Derwing, 1992), suggesting that the effect is not language specific.

2.5.6. Experimental Challenges

One of the major challenges to investigating ambisyllabicity experimentally is that many tasks simply do not allow for ambisyllabic responses. Syllable reduplication and repetition tasks do not provide enough information to determine whether a speaker has ambisyllabified a consonant. Nor do substitution tasks. Tasks in which participants choose their preferred syllabification often do not present an ambisyllabic option. While a preference for syllabifying intervocalic consonants as onsets may seem to indicate that the onset principle takes precedence over other principles, this cannot be concluded if ambisyllabic options are not presented.

Syllable reversal tasks, as well as fragment insertion and pause insertion tasks, all allow for ambisyllabic responses. Though ambisyllabic responses are possible in pause insertion tasks, they are subject to greater orthographic influence, because the written counterpart, the frequently used slash-insertion task, does not allow for ambisyllabicity. The strong relationship between orthography and syllabification (Treiman & Danis, 1988) can likely speakers’ reluctance to insert oral syllable boundaries that would not be permitted orthographically. This may be especially true if the speaker performs both oral and written tasks in the same experiment.

Thus far, research has identified two important ways that orthography affects syllabification and these effects need to be carefully addressed. Eddington et al. (2013)
found that in written tasks, speakers were highly unlikely to violate orthotactic constraints. For example, participants generally avoid placing ‘ck’ or ‘ll’ syllable-initially. This effect may bias participants against syllabifying certain segments in the onset if doing so forces them to violate orthographic conventions. Orthography also influences a variety of oral phonological tasks, including many tasks that can be performed without orthographic knowledge (Seidenberg & Tanenhaus, 1979). Treiman and Danis (1988) as well as Schiller et al. (1997) have found evidence that English speakers produce ambisyllabic responses significantly more frequently when the stimulus has two consonants in the orthographic representation. In response to oral stimuli that have two consonants in the orthographic representation, Treiman and Danis (1988) found that participants gave ambisyllabic responses up to 80% of the time, and that orthography was the greatest predictor of ambisyllabicity. In a later experiment, Treiman, Bowey, and Bourassa (2002) demonstrated that younger children were not susceptible to the effects of spelling on oral syllabification. They found that performance was similar on phonologically analogous words such as ‘habit’ and ‘rabbit’ that differ in orthographic representation. This is clear evidence that speakers with no orthographic knowledge behave differently, and raises the question of whether previous tasks have been successful in evaluating speakers’ subconscious understanding of syllable structure. It is clear that in order to access this knowledge orthographic influence needs to be eliminated.

One way to deal with effects of orthography is by using non-word stimuli. There are few previous experiments that use non-word stimuli to investigate syllabification and many are subject to other limitations. Ishikawa (2002) used non-word stimuli in his experiment, however participants were asked to choose between two preferred syllabifications, rather than provide their own syllabification judgements. While this design eliminates the effects of orthography, it does not investigate ambisyllabicity because participants were not presented with ambisyllabic examples as possible responses. Redford and Randall (2005) also used non-word stimuli, and participant responses were not restricted. However, participants were asked to write down the stimuli. Arguably, this is not an effective method of reducing orthographic effects.
The use of non-word stimuli can be an effective way to address other experimental challenges. Ultimately, it is difficult to control for all relevant phonological factors when stimuli are restricted real words. Previous research has investigated the effects of stress, intervocalic consonant type, vowel type and orthography, but controlling for these factors in the stimuli often forces experimenters to use words with low frequency, words that have variable pronunciation, or words that are morphologically complex. In effect, this may introduce a new set of uncontrolled variables that affect syllabification.
Chapter 3.

Experiment 1

3.1. Purpose

The primary purpose of the first experiment was to investigate the effect of onset type on the syllabification of intervocalic consonants, and determine whether onset type can be used to predict the occurrence of ambisyllabic responses. This experiment aims to investigate this in a context where effects of orthography are reduced, which is achieved by using non-word stimuli. Unlike previous experiments that have used non-word stimuli e.g. Ishikawa (2002), Redford and Randall (2005), this research will allow participants to make their own syllabification judgements, rather than choosing a preferred syllabification.

3.2. Overview

This experiment used a syllable reversal task in which native speakers of English were presented with a bisyllabic non-word stimulus and asked to produce a response by reversing the order of the syllables. For example, the participants were presented with a non-word such as 'kolub' and asked to reverse the order of the syllables. They responded with ‘lub.ko’, ‘lub.kol’, ‘ub.kol’ or something else, depending on how the intervocalic consonant was affiliated. There were a total of 137 stimuli, and participants were presented with three separate tokens of each for a total of 411 trials. The stimuli were randomized for each participant. The experiment took approximately one hour to complete.
3.3. Stimuli

In order to create the bisyllabic non-word stimuli, a list of initial syllables was created. Then, a list of final syllables was created. One initial syllable was paired with one final syllable, and an intervocalic consonant was inserted between the two vowels. Intervocalic consonants were restricted to liquids /l/ or /r/ and nasals /m/ or /n/. Liquids and nasals were used in intervocalic position as a means of promoting ambisyllabicity, given that these consonants are more likely to be ambisyllabified than obstruents (Treiman & Danis, 1988). Similarly, all initial syllables were stressed, as stress on the preceding syllable also promotes ambisyllabification of intervocalic consonants. Initial syllables were created using five different vowels: tense vowels /i/, /o/, /e/ and /u/, as well as the vowel /ɑ/ which is not specified as tense or lax. The vowel /ɑ/ was included among the tense vowels because like tense vowels /ɑ/ can appear word-finally in English. These vowels were chosen so as not to force participants to produce reversals with sequences that are not licit in English i.e. lax vowels in word-final position.

In order to examine the effect of onset type, the stimuli were varied in three ways, according to onset type: onsetless, singleton onset, cluster onset (two consonants). Onsetless stimuli consisted of only the vowel. Stimuli with singleton onsets began with initial obstruents /p/, /t/, or /k/ and stimuli with cluster onsets were created using the same obstruents, /p/, /t/, or /k/ + a sonorant, either /w/, /l/ or /r/. This created a list of 9 onset clusters: /pl/, /tl/, /kl/, /pw/, /tw/, /kw/, /pr/, /tr/, /kr/. There were a total of 13 possible onsets (3 singletons, 9 clusters and the zero onset). Each possible onset was paired with all of the five vowels to create initial syllables.

Because the stimuli were non-words, it was important to ensure that stimuli were composed of syllables that were phonotactically probable in English. This was done using a phonotactic probability calculator developed by Vitevitch and Luce (2004). This calculator determines the phonotactic probability of sequences by calculating the probability of each biphone within the sequence, then providing the sum of the biphone probabilities. All syllables containing a biphone with a probability below 0.001 were removed. This eliminated syllables with onset clusters that were phonotactically illicit i.e. /tl/ or highly unlikely, for example the syllable /kwu/ was eliminated as /wu/ has a
biphone probability below 0.001. In order to reduce the number of syllables with cluster onsets, all syllables with a cluster onset and an overall phonotactic probability that did not fall within two standard deviations of the mean were eliminated. This reduced number of syllables with cluster onsets from 50 to 24. This helped to eliminated syllables that could be perceived as common English morphemes, for example /pri/.

Results from the pilot study indicated that syllables with /kw/ onsets may be more likely to elicit ambisyllabic responses. In order to contrast this /tw/ onset clusters were added back to the stimuli, in spite of their low phonotactic probability.

After eliminating 26 syllables according to phonotactic probability, a total of 44 initial syllables remained – 24 with cluster onsets, 15 with singleton onsets and 5 with zero onsets. Each of these syllables was then paired with all four of the intervocalic consonants /m/, /n/, /l/ and /r/. All stimuli in which a segment was repeated more than once were eliminated. For example, any initial syllable having the liquid /r/ in the cluster onset could not also have /r/ as an intervocalic consonant.

Final syllables were created using the same five vowels used to create initial syllables. There were 8 possible codas: /p/, /b/, /v/, /t/, /d/, /s/, /z/, /k/. In order to calculate the biphone probabilities of second syllables, which will appear following another syllable, the probability of the biphone in word internal position was calculated. In order to do this, /t/ was appended to the beginning of all S2s and the biphone probability of the vowel and coda only was calculated. All second syllables with a biphone probability of less than 0.001 were removed. A total of 36 possible final syllables were created.

Once final syllables were created, they were appended to the initial syllable + intervocalic consonant.
<table>
<thead>
<tr>
<th>Stimuli Type</th>
<th>Onset Consonant</th>
<th>Onsets</th>
<th>Intervocalic Consonant</th>
<th>V2</th>
<th>Codas</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onsetless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singleton</td>
<td>p, t, k</td>
<td>p, t, k</td>
<td></td>
<td>i, e, o, u, a</td>
<td>l, m, n, r</td>
<td>imup, peliv</td>
</tr>
<tr>
<td>Cluster</td>
<td>p + l, r, w</td>
<td>pl, pr, (pw)</td>
<td>i, e, o, u, a</td>
<td>l, m, n, r</td>
<td>b, d, k, s, t, v, z</td>
<td>plerik, trinev, kweras</td>
</tr>
<tr>
<td></td>
<td>t + l, r, w</td>
<td>kl, kr, kw</td>
<td>i, e, o, u, a</td>
<td>l, m, n, r</td>
<td>b, d, k, s, t, v, z</td>
<td>plerik, trinev, kweras</td>
</tr>
<tr>
<td></td>
<td>k + l, r, w</td>
<td>(tl), tr, tw</td>
<td>i, e, o, u, a</td>
<td>l, m, n, r</td>
<td>b, d, k, s, t, v, z</td>
<td>plerik, trinev, kweras</td>
</tr>
</tbody>
</table>

It was ensured that no segment was repeated within a stimulus. Any stimulus resembling a real English word was eliminated. A total of 137 stimuli remained. There were 19 onsetless stimuli, 36 stimuli with singleton onsets, and 82 stimuli with cluster onsets. Stimuli are listed in Appendix A.

The stimuli for Experiment 1 were recorded in a single session. They were recorded by a female native speaker of English, in Audacity. Six tokens of each stimuli were recorded in the carrier phrase “Please say x clearly”. Noise was removed and each of the stimuli were then extracted. Once extracted, the three best tokens of each stimulus were chosen based on the volume and clarity of the recording. Stimuli were cut at zero crossings, normalized for amplitude, and 100ms of silence were added to the beginning of each stimulus. The stimuli were not subjected to any further phonetic manipulations.

### 3.4. Participants

Twenty-three undergraduate students participated in the experiment. However, data from 5 participants was discarded due to recording error. Participants were recruited using the Linguistics Research Participation System, which allowed them to receive course credit towards a Linguistics course. Participants were aged 19-35 and reported normal hearing. Participants were asked to complete a language background survey, in order to establish their language background and their linguistic knowledge. All participants were native speakers of English, though some participants reported speaking a second language.
3.5. Procedure

The experiment was conducted in a laboratory setting. Once informed consent was obtained, participants were asked to complete a brief language background survey. The participants were then led into a private room where the experimenter gave a brief overview of the experiment. Participants were informed that the experiment was a word-game task with 411 trials, and that it would take approximately one hour. Participants were also informed that they would go through an on-screen training which would include some examples and some practice trials. They were told to clarify with the experimenter if they were unsure about the instructions provided in the training. They were also instructed on how to use the lab equipment such as the headphones and volume control, as well as the microphone and keyboard.

Participants then began the test session, which started with the on-screen training. In order to avoid preconceived notions of syllabification special care was taken in the participant training. As is customary in syllabification tasks, the word ‘syllable’ was not explicitly used in the instructions. Participants were instructed that they would be playing a word game, where they would be presented with words from a made up language and asked to reverse the parts. There were four real-word examples. A variety of examples were given to ensure that the instructions did not express any expectations. Two example consisted of the compound words ‘greenhouse’ and ‘teacup’, one example consisted of a word containing a medial cluster ‘mister’ and one example had single intervocalic consonant ‘pillow’. In the example, the intervocalic consonant was treated as ambisyllabic, so that participants were aware that this was an option. Previous experiments e.g. Treiman and Danis (1988) did not include these types of examples in participant training. Instead, they used only compound words, which could easily be split at morpheme boundaries e.g. ‘grandfather’.

Examples were followed by four real-word practice trials, consisting of two compound word stimuli ‘washdish’ (dishwash) and ‘heldhand’ (handheld), as well as one morphologically complex stimulus ‘lyfair’ (fairly), and one reversal where the medial consonant was ambisyllabic ‘pypop’ (poppy).
3.6. Results

3.6.1. Pilot Results

Before running the full experiment a shortened version was run as a pilot study. There were a total of 29 stimuli, and 10 participants were presented with two separate tokens of each. There were a total of 58 trials per participant, which took approximately ten minutes to complete.

The pilot study intended to determine whether participants would produce enough ambisyllabic responses for analysis. In previous experiments (Treiman & Danis, 1988) it has been found that ambisyllabic responses are less frequent when the critical consonant is preceded by tense vowel. Additionally, the pilot intended to confirm that the experiment was clear and that participants understood the task. According to Côté and Kharlamov (2011) syllable reversal tasks are often prone to errors, even when real word stimuli are used.

Participants had no difficulty understanding the task: all participants performed the task as intended, and no participants required instructions further to those given on screen. Of a total of 580 responses, there were 35 ambisyllabic responses (6%). These results were judged as sufficient to proceed with the full experiment. An interesting finding from the pilot was that participants seem to ambisyllabify frequently when stimuli had a /kw/ onset. For this reason /tw/ onsets were added back to the stimuli, in order to contrast with /kw/ onsets.

3.6.2. Coding

There were four possible ways that participant responses could be coded: 1) CODA - the intervocalic consonant was syllabified as the coda of the initial syllable, 2) ONSET - the critical consonant was syllabified as the onset of the final syllable, 3) AMBI - the critical consonant was syllabified as both the coda of the initial syllable and the onset of the final syllable 4) OTHER - the critical consonant was not treated as an onset or coda. There were a number of ways in which this could occur e.g. metathesis, deletion, no response, etc.
### Table 3.2 Coding Responses

<table>
<thead>
<tr>
<th>Stimuli Type</th>
<th>Example</th>
<th>Response Type</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onsetless</td>
<td>imup</td>
<td>CODA</td>
<td>up-im</td>
</tr>
<tr>
<td></td>
<td>imup</td>
<td>ONSET</td>
<td>mup-i</td>
</tr>
<tr>
<td></td>
<td>imup</td>
<td>AMBI</td>
<td>mup-im</td>
</tr>
<tr>
<td>Singleton Onset</td>
<td>talok</td>
<td>CODA</td>
<td>ok-tal</td>
</tr>
<tr>
<td></td>
<td>talok</td>
<td>ONSET</td>
<td>lok-ta</td>
</tr>
<tr>
<td></td>
<td>talok</td>
<td>AMBI</td>
<td>lok-tal</td>
</tr>
<tr>
<td>Cluster Onset</td>
<td>krinev</td>
<td>CODA</td>
<td>ev-krin</td>
</tr>
<tr>
<td></td>
<td>krinev</td>
<td>ONSET</td>
<td>nev-krni</td>
</tr>
<tr>
<td></td>
<td>krinev</td>
<td>AMBI</td>
<td>nev-krin</td>
</tr>
</tbody>
</table>

In many of the responses, a segment or segments within the stimuli were produced incorrectly. For example, ‘oliv’ is produced as ‘liv.el’, where the vowel in the initial syllable of the stimuli, /a/ is incorrectly produced as /e/ in the reversal. This response was still considered AMBI, rather than OTHER. In these cases, both the repetition and the reversal are produced with an incorrect segment, suggesting that the participant had misheard the initial stimulus.

Three research assistants assisted in the coding of data. There was a 93% average pairwise agreement between all those coding the data. All disagreements were instances in which the response was coded as OTHER by one coder and as something else by another coder. If the OTHER response was a result of the coder being unable to hear the response clearly, the OTHER response was accepted as correct. In cases where the coder was able to hear the recording but unable to code it, the provided transcription was referenced for further information.

### 3.6.3. Results

There were a total of 7398 responses collected from 18 participants. Fifteen out of the eighteen participants produced at least one ambisyllabic response. There was variability within speakers: participants did not respond to each token of a stimulus in the same way each time.
In the majority of responses (99%), participants syllabified the medial consonant as ONSET. There were 67 AMBI responses, and there were 18 CODA responses. There were also 109 OTHER responses where the medial consonant was not treated as an onset or coda e.g. metathesis, deletion, etc. In the majority of OTHER response (68%), participants failed to respond to the stimulus. Aside from this, there were 35 responses where participants attempted the syllable reversal, but did not produce any of the expected results. The most common error was metathesis of segments. These responses will be discussed further in Chapter 3.6.4.

In a similar experiment, Treiman and Danis (1988) used Friedman analyses of variance by ranks to establish which response types were preferred in which contexts. This was useful because their data showed greater variability in response types, similar proportions of different response types, and no distinct preferences were evident. In the current experiment, there were an overwhelming number of ONSET responses in all contexts, and it was clear that ONSET was the preferred response type. In this case, it was of more interest to determine whether stimuli onset type had any effect on the speakers’ response type. In order to determine if a relationship exists between these variables, a chi-square test would typically be used, given that the response data are categorical. However, in this experiment participants were exposed to multiple tokens of the same stimuli which constitutes a repeated measures design. As such, a chi square test was not suitable for this data and descriptive statistics were examined instead. The data exhibited trends indicating that some phonological factors are correlated with an increase in ambisyllabicity.

Of a total of 4266 trials having stimuli with medial nasals, 0.73% elicited ambisyllabic responses. Of a total of 3132 trials having stimuli with medial liquids, 1.15% elicited ambisyllabic responses. This is consistent with Treiman and Danis (1988) who also found that liquids were more likely to be ambisyllabified than nasals.

2.6 percent of responses to onsetless stimuli were ambisyllabic, compared to 0.9 percent of responses to stimuli with singleton onsets and 0.5 percent in response to stimuli with cluster onsets. These trends in suggest that ambisyllabification is more common when there are fewer consonants in the onset.
Table 3.3. Experiment 1 Response Type Percentages by Onset Type

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<tr>
<th>Onset Type</th>
<th>OTHER</th>
<th>CODA</th>
<th>ONSET</th>
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<tr>
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<td>Singleton Onset</td>
<td>1.5</td>
<td>0.87</td>
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<tr>
<td>Cluster Onset</td>
<td>1.3</td>
<td>0.0</td>
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</table>

3.7. Discussion

Ambisyllabic responses, though infrequent, fit the predicted pattern. The percentage of liquids that were ambisyllabified was higher than the percentage nasals that were ambisyllabified, which is expected based on Treiman and Danis (1988). Stimuli with fewer onset consonants elicited proportionally more ambisyllabic responses than stimuli with more onset consonants, which suggests that onset type affects syllabification. By extension, this suggests that onsets do contribute to syllable weight.

The infrequency of ambisyllabic ity is in itself an interesting finding. Previous experiments, such as Treiman and Danis (1988) and Schiller et al. (1997) both demonstrated a much higher occurrence of ambisyllabicity, therefore suggesting that ambisyllabification is a strategy regularly employed by speakers in syllabification tasks, especially in the predicted contexts. This supports theoretical validity of ambisyllabicity. Conversely, this experiment showed an extremely low occurrence of ambisyllabicity and an overwhelming preference to syllabify single intervocalic consonants as onsets, challenging the validity of ambisyllabicity. However, the results do not necessarily support theories of resyllabification either. Resyllabification theories predict that in surface form intervocalic consonants are syllabified as codas. However, this experiment found an even lower occurrence of CODA responses than AMBI responses. The argument could be made that syllabification tasks access the Basic Syllable Composition of the word, i.e. the underlying form, in which intervocalic consonants are expected to be syllabified as onsets. However, there still remains a lack of evidence that intervocalic consonants are syllabified as codas, or anything other than onsets, at any stage.
It is worth noting, that Treiman and Danis (1988), did in fact find that CODA responses were given frequently, and in some cases slightly more frequently than ONSET and AMBI responses. In addition, they found a lower occurrence of OTHER responses, suggesting that overall, participants had more difficulty performing the task. Within the OTHER responses, a pattern emerged: while many of the OTHER responses were stimuli that the participant did not respond to, in the majority of responses where an answer was given, participants syllabified the critical consonant in both syllables, but it was not treated as both an onset and a coda. For example, ‘imup’ was reversed to produce ‘mup.mi’, and ‘pilov’ was reversed to produce ‘lov.pli’. Some of these differences can likely be attributed to the use of non-word stimuli, as this was the key difference between this experiment and previous experiments. It has been shown that it is more difficult for participants to segment VC sequences when the consonant is more sonorous, and it may become even more difficult without referencing the orthographic representations. A similar effect has been found in children, by Geudens, Sandra, and Van den Broeck (2004) who showed that children’s early reading skills were correlated with their ability to segment VC and CV sequences.
Chapter 4.

Experiment 2

4.1. Purpose

The purpose of Experiment 2 was to further investigate patterns observed in Experiment 1, by using stimuli that had both tense and lax vowels in V1. Experiment 1 demonstrated that ambisyllabic responses were more common when there are fewer consonants in the onset of a stimulus. However, the frequency of ambisyllabic responses was very low. This experiment aims to determine if the effect onset type is attested in a task where stimuli have lax vowels, and whether the effect will be more prominent, as lax vowels are expected to elicit more ambisyllabicity.

4.2. Overview

Experiment 2 used the same methodology as Experiment 1.

4.3. Stimuli

Experiment 2 used a mixed design, where participants were presented with stimuli that contained either a tense or a lax vowel preceding the intervocalic consonant. Half of the stimuli from Experiment 1 were redesigned in such a way that the tense vowel was substituted for the lax counterpart. Stimuli from Experiment 1 were grouped into near minimal pairs: each pair had the same onset type (onset, cluster, onsetless), same intervocalic consonant type (liquid or nasal), and the same V1. One of each minimal pair had its V1 replaced with the lax counterpart. For example, ‘twilop’ and
‘twirut’ were paired together and the V1 or ‘twirut’ was replaced to create the new stimuli ‘twirut’, whereas ‘twilop’ was unchanged. Stimuli are listed in Appendix B.

In Experiment 2, all stimuli with tense vowels were taken from Experiment 1. New stimuli with lax vowels were recorded using the same procedure as Experiment 1. The same female native speaker who recorded stimuli for Experiment 1 recorded all new stimuli in Audacity, during a single recording session. Stimuli were recorded in the same carrier phrase, and were subjected to the same manipulations.

4.4. Participants

Fifteen undergraduate and graduate students participated in the experiment. However, data from three participants was discarded due to recording error. This is likely because speakers were not speaking loudly enough, or speaking into the microphone. The experimenter did not monitor the recording during the session, so as to put the participants at ease.

Two participants were recruited using the Linguistics Research Participation System, which allowed them to receive course credit towards a Linguistics course. The remainder of the participants were recruited by word of mouth. All participants were aged 19-35 and reported normal hearing. Participants were asked to complete the same language background survey used in Experiment 1, which served to establish their language background and linguistic knowledge. All participants were native speakers of English, though some participants reported speaking a second language.

4.5. Procedure

The methodology used in Experiment 2 was almost the same as the methodology of Experiment 1. There was one small change: participant breaks were built in to the experiment after each 100 trials.
4.6. Results

There were a total of 5256 responses collected from twelve participants. Nine out of the twelve participants produced at least one ambisyllabic response. As in Experiment 1, the majority of speakers produced at least one ambisyllabic response. This experiment also found variability within speakers: participants did not respond to each token of a stimulus in the same way each time.

Ambisyllabic responses were more frequent in Experiment 2 than in Experiment 1 (8% vs 1%). However, in the majority of responses (88%) participants syllabified the medial consonant as ONSET. In many ONSET responses, when stimuli had lax V1, participants produced a tense vowel in the open syllable. It was uncommon for participants to leave lax vowels in open syllables. For example, ‘kırus’ reversed to produce ‘rus.ki’, with the vowel /ɪ/ lengthened to /i/. There were 420 AMBI responses, 50 CODA responses, and 117 OTHER responses. In 52% of OTHER responses, participants failed to respond to the stimuli. Aside from this, there were 56 responses where participants attempted the syllable reversal, but did not produce any of the expected results. The most common errors included deletion of the critical consonant and the addition of either a nasal or liquid after a lax vowel. As in Experiment 1, there were some examples where the critical consonant was placed in both syllables, but was not considered ambisyllabic. There was also a new response type in this experiment: some participants provided two responses to one stimulus. In these responses, participants produced an AMBI response as well as a CODA response. There were 25 responses of this type, from two participants.

Of a total of 3132 trials having stimuli with medial nasals, 7.5% elicited ambisyllabic responses. Of a total of 2124 trials having stimuli with medial liquids, 8.7% elicited ambisyllabic responses. This is consistent with findings from Experiment 1, and is also consistent with the findings of Treiman and Danis (1988). Of a total of 2664 trials having stimuli with a lax V1, 11.4% elicited AMBI responses. Of a total of 2592 trials having stimuli with a tense V1, 4.4% elicited AMBI responses. This is consistent with the findings of Treiman and Danis (1988) that lax vowels elicit more ambisyllabic responses. This also supports the theoretical principle of lax vowel closing.
Experiment 2 replicated many of the results from Experiment 1. Again it was found that most of the speakers made at least one ambisyllabic response. Liquids were ambisyllabified more often than nasals. While ambisyllabicity was still infrequent, there was an increased number of ambisyllabic responses. Ambisyllabicity was mostly produced in response to lax vowels, as expected. However, in Experiment 2 there was also an increase in the percentage of ambisyllabic responses to tense vowels. The lack of variety in response type observed in Experiment 1 may be explained by participants’ desire to consistently apply the same syllabification strategy to each stimulus. In Experiment 2, participants began producing ambisyllabic responses in order to satisfy lax vowel closing. It is possible that once participants were more comfortable using ambisyllabicity as a syllabification strategy, they began applying it in other contexts as well.

Ambisyllabic responses exhibited a similar pattern in Experiment 2 as in Experiment 1, with some important differences. Ambisyllabicity was least frequent in
response to stimuli with two consonants in the onset. However, the percentage of ambisyllabicity in response to onsetless stimuli and stimuli with a singleton onset was nearly the same. The fact that onsetless stimuli and stimuli with singleton onsets were treated the same way in the syllabification task indicates that the onsetless syllables and syllables singleton onset are similar in weight. Stimuli with cluster onsets yielded fewer ambisyllabic responses, which is expected based on the assumption that syllables with cluster onsets are heavier. In this experiment, cluster onsets included sonorant consonants whereas singleton onsets did not. Therefore, results could also suggest that syllables with sonorants in their onset are heavier than syllables that only have obstruents in the onset, regardless of the total number of onset consonants.

An interesting outcome of Experiment 2 was that some participants provided two responses to certain stimuli. The participant would provide the AMBI response and then follow with the ONSET response (or vice versa). There were no instances where participants produced a CODA and ONSET response, nor were there any responses in which the participant provided an AMBI and CODA response. This seems to indicate a strong dispreference for syllabifying intervocalic consonants in coda position, even more so than the dispreference for ambisyllabicity.

In many cases, if presented with a stimulus having a lax V1, participants produced the tense counterpart to the vowel and left it in an open syllable. Again, this indicates that participants prefer that lax vowels are followed by a coda consonant. The use of this strategy instead of ambisyllabicity suggests that ambisyllabicity is avoided. In this experiment it seems that vowel tensing is more natural for speakers. This strategy was not reported by Treiman and Danis (1988), possibly because participants are less inclined to apply this to real words that they are more familiar with.
Chapter 5.

Discussion and Conclusion

The trends in the data suggest that onset type affects syllabification of intervocalic consonants. When participants were asked to syllabify single intervocalic consonants, AMBI responses were proportionally less frequent if the preceding syllable had a cluster onset. AMBI responses were observed proportionally more frequently in response to onsetless stimuli, which aligns well with the minimum syllable weight requirements proposed by Giegerich (1992), Hammond (1999), etc. This also supports the claim that onsets contribute to syllable weight (Kelly, 2004; Ryan, 2011, 2014) in a system where syllable weight is a gradient rather than binary system.

According to most theories of syllable weight, tense vowels meet minimum weight requirements, whereas lax vowels do not. Usually, lax vowels attract coda consonants to resolve this. Therefore, it is expected that ambisyllabicility will be more frequent when lax vowels precede intervocalic consonants, as opposed to tense vowels. Comparing results from Experiment 1 to those of Experiment 2, this was found to be the case. These findings supports arguments from Kelly (2004) and Ryan (2011, 2014) that syllable weight can also be affected by onset consonants in English. A vowel preceded by more onset consonants is predicted to be a heavier syllable than a vowel preceded by fewer onset consonants. Although most accounts of syllable weight are binary systems, which propose that a syllable must be considered either light or heavy, weight distinctions may still exist within these categories. When considering a syllable with a lax vowel, additional onset weight is important. If lax vowels attract coda consonants as a means of increasing syllable weight, lax vowels with additional onset weight are less likely to need coda consonants. Tense vowels with additional onset weight may also reject coda consonants as a means of keeping syllable weight below the trimoraic
maximum. This explains why variation in onset type can be used to predict variation in the way intervocalic consonants are syllabified.

It was also observed that adding a consonant to the onset of a syllable does not increase the proportion of ambisyllabicity uniformly. The difference in the proportion of ambisyllabicity between stimuli with no onsets, stimuli with singleton onsets and stimuli with cluster onsets was not equal. This suggests that onset weight may not be determined entirely by the number of consonants in the onset, but may be determined by the properties of the onset in general. In these experiments, not only did cluster onsets in the stimuli have more consonants, but they also included sonorant consonants whereas the singleton onsets did not. Sonorant consonants can be considered more vowel-like than obstruents because, like vowels, they are [+sonorant]. In languages such as Slovak, liquids such as /l/ and /r/ commonly make up entire syllables (Pouplier & Beňuš, 2011). It has been argued that syllabic consonants exist in English as well (Toft, 2002; Trager & Bloch, 1941). This may explain why onsets that include sonorants have a greater impact on syllable weight, and in turn why the cluster onsets in this experiment were less likely to elicit ambisyllabicity. Further research should seek to compare single sonorant onsets to those with single obstruent onsets in order to provide more insight.

In spite of the observation that onsetless syllables elicit more ambisyllabicity than syllables with onsets, results still challenge the hypothesis that ambisyllabicity is a valid syllabification strategy. In contexts combining the onset effect with the effect of vowel type, the highest percentage of ambisyllabicity was observed at 13.6%. While it is expected that this context elicit the highest proportion of ambisyllabicity, which it did, overall percentage of ambisyllabicity was still much lower than expected compared with other research e.g. Treiman and Danis (1988). If ambisyllabicity is theoretically valid, we expect a reliable preference for ambisyllabicity in predicted contexts. While ambisyllabic responses were higher in the predicted contexts, they were not preferred in any context. In some cases ambisyllabicity was so strongly avoided that participants preferred to lengthen final vowels rather than close syllables with an ambisyllabic consonant. This strategy was not reported in Treiman and Danis (1988).
The results of this study have interesting implications for resyllabification theories. Resyllabification theories do not make explicit predictions about how speakers will behave in syllabification tasks given intervocalic consonants preceded by stressed vowels. This is because they claim that intervocalic consonants are syllabified differently in surface form, and in underlying form. If syllabification tasks are assumed to access surface forms, speakers would be expected to syllabify single intervocalic consonants as codas. If syllabification tasks are assumed to access underlying forms, speakers would be expected to syllabify single intervocalic consonants as onsets. This experiment found that speakers syllabify intervocalic consonants as onsets in most cases, even when conditions for ambisyllabicity are optimized. This suggests that speakers are accessing underlying forms when performing this task. However, in similar phonological contexts, Treiman and Danis (1988) found that while the proportion of coda responses was slightly higher than the proportion of onset responses there was a great deal of variation. An important difference between the two experiments is that Treiman and Danis (1988) used real word stimuli, whereas the current study did not. The lack of variation in response to non-word stimuli suggests that participants may only have access to the underlying representation when processing these stimuli, perhaps because a so-called surface form only exists for real words. Previous research examining the perception of spoken words has also found that non-words are treated differently than real words, and that non-words are more susceptible to the effects of phonotactics, which occur at the sublexical level (Vitevitch & Luce, 1998).

The aim of this research was to further investigate ambisyllabicity and attempt to predict its occurrence. This research corroborated findings of Treiman and Danis (1988) that lax vowels in V1 elicit more ambisyllabicity than tense vowels, and that intervocalic liquids are more likely to be ambisyllabic than nasals. Results showed that syllables having more onset consonants elicit less ambisyllabicity and likewise that syllables with fewer onset consonants elicit more ambisyllabicity. This was the expected outcome based on the hypothesis that onsets can contribute to syllable weight. There were substantial differences in the speakers’ behaviour in this study compared to previous research, suggesting that syllabification was greatly affected by the use of non-word stimuli. Participants had more difficulty with the task and there was significantly less variability in response type, specifically a low occurrence of ambisyllabicity and coda.
responses. Additionally, tensing of final vowels was shown to be the preferred strategy to avoiding lax vowels in open syllables, rather than ambisyllabicity. In conclusion, though ambisyllabicity is increased when there are fewer consonants in the onset of a preceding syllable, it appears that overall ambisyllabicity is largely influenced by orthography and that speakers prefer to syllabify intervocalic consonants as onsets.
References


## Appendix A.

### Stimuli for Experiment 1

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| kwamod    | trenop         |              |
| kwanus    | trilap         |              |
| kwarus    | trimev         |              |
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### Appendix B.

**Stimuli for Experiment 2**

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