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A phonetic examination of phonological ambisyllabicity: Focusing on temporal and spectral characteristics*

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Lee, Joo-Kyeong and Yuhyeon Seo. 2019. A phonetic examination of phonological ambisyllabicity: Focusing on temporal and spectral characteristics. *Linguistic Research* 36(1), 91-110. This paper casts doubt on the existence of phonological ambisyllabicity and attempts to find its phonetic substances both temporally and spectrally. An intervocalic consonant becomes ambisyllabic when preceded by a stressed lax vowel, a theoretical apparatus to make the preceding stressed light syllable heavy by linking the intervocalic consonant to both preceding coda and following onset. In the experiment, temporal durations of ambisyllabic and non-ambisyllabic intervocalic consonants were compared, where consonants were varied with obstruents, nasals, and liquids. For a spectral measurement, lateral tokens were investigated because lateral /l/is the only consonant which shows a maximum allophonic difference between onset and coda (clear-[l] and dark-[ɫ]). Their F2-F1 values were compared among the laterals in ambisyllabic, non-ambisyllabic, word-initial onset, and word-final coda positions. Results showed that ambisyllabic and non-ambisyllabic consonants were not significantly different in duration for all three categories and that F2-F1 values of the laterals were not significantly different between ambisyllabic and non-ambisyllabic positions. This is not consistent with the phonological analysis. They were both distinctive from onset or coda laterals. This indicates that there might be a new allophony occurring in the intervocalic position where the preceding syllable is, whether its vowel is tense or lax, stressed. **(University of Seoul · Korea University)**

Keywords ambisyllabicity, intervocalic, multiple linkage, syllabification

1. Introduction

Ambisyllabicity in English has merged from a theory-based phonological apparatus to prevent a stressed syllable from being a light syllable. English has a weight-sensitive stress system where a stressed syllable should be heavy and

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an unstressed syllable may be light. When an intervocalic consonant is associated with the onset of the following consonant according to the Onset Maximization principle, it does not satisfy the heaviness requirement of stressed syllables if the preceding syllable contains a lax vowel. Due to the fact that a lax vowel takes up only one mora, a syllable, if having a lax vowel but not closed by a coda consonant, is a light one. As shown in the example of 'color' /kʌ-ləɹ/ in Figure 1, the preceding syllable turns out to be light because the lax vowel /ʌ/ is associated with one mora without a coda under the Rhyme as in Figure 1 (a). This incurs a serious violation of the principle that a stressed syllable should be heavy in English; therefore, the intervocalic consonant /l/, which is the onset of the following syllable, is intentionally linked to the preceding syllable, creating its coda node (Kahn 1976; Gussenhoven 1986; Hayes 2009). The intervocalic consonant /l/ now straddles both coda and onset, and it is referred to as an ambisyllabic consonant as shown in Figure 1 (b).

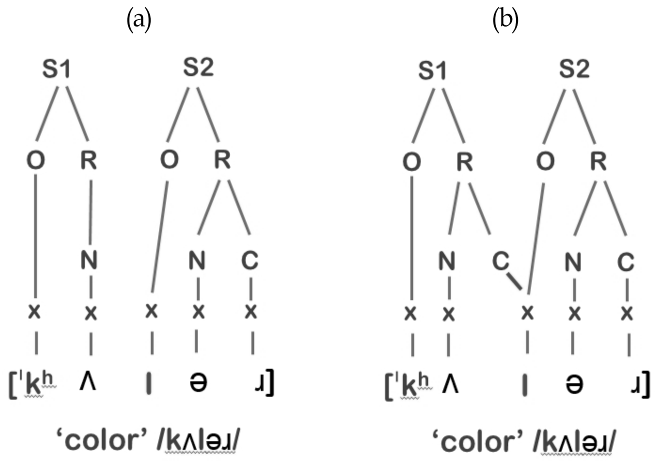

Figure 1. Syllable structures of color /kʌ-ləɹ/: ambisyllabic consonant /l/

If the ambisyllabic representation shown in Figure 1 (b) holds true, how is the ambisyllabic consonant /l/ realized in phonetics or actual speech? Since it is linked to onset and coda in the syllable structure, it should have both features of clear-[l] and dark-[ɫ].

Ambisyllabic consonants are sometimes compared with geminates. They are similar in that both of them are dominated by two adjacent syllables as shown in Figure 2. However, their features are distinctive from each other because ambisyllabic consonants do not hold more than one mora in a syllable structure as in Figure 2 (a), while geminates have two. For instance, an Arabic word /katab/ spelled as *khattab* has a geminate /t/ which is linked to two x-timing moras as shown in Figure 2 (b). Geminates are then temporally longer than non-geminates.

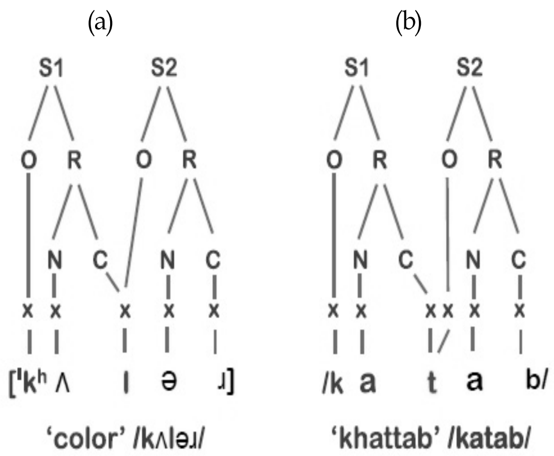

Figure 2. The syllable structure of 'color' and the syllable structure of an Arabic word 'khattab'

2. Previous approaches to ambisyllabicity

While there have been a number of phonological studies on ambisyllabicity so far, it is not until quite recently that a few phonetic researches on these special consonants have been conducted. Starting from Kahn (1976) who referred to ambisyllabicity in order to comply with the syllable structure system that he proposed, it has been argued that an ambisyllabic consonant is multiply linked to both the preceding and the following syllables (Kahn 1976; Gussenhoven 1986; Hayes 2009). However, this approach has not been exempt from criticism because it violates the Strict Layer Hypothesis which demands that a unit of a given level of the hierarchy be exhaustively contained in the superordinate unit of which it is part (Selkirk 1984; Nespor and Vogel 1986).

Duanmu (2010) suggested that the Weight-Stress Principle be applied to ambisyllabic consonants. According to the Weight-Stress Principle, stressed syllable should be heavy. When the preceding syllable is stressed and the nucleus is a lax vowel, the intervocalic consonant should be associated with the coda of the preceding syllable to make it heavy. However, the Weight-Stress Principle contradicts the Onset Maximization Principle which has been cross-linguistically derived from a universal preference of onset over coda.

The Onset Maximization principle requires that intervocalic consonants must be assigned to the onset position of the following syllables as long as they conform to universal and language specific conditions (Kahn and Daniel 1976). Applying this rule to ambisyllabic consonants, some phonologists have insisted that they should be linked to the onset of the following syllable (Kiparsky 1979; Jensen 2000; Harris 2004, 2006; Bermudez-Otero 2007). However, this approach is also untenable because it leaves the preceding syllable light and it is not qualified to bear stress.

What was proposed as a solution to the above problem is resyllabification (Selkirk 1982; Borowsky 1986; Wells 1990). This approach is a step-by-step syllabification which states that an ambisyllabic consonant preceded by a stressed lax vowel is first associated with the onset of the following syllable according to the Onset Maximization Principle, and then it is resyllabified to the coda of the preceding one so as to satisfy the Weight-Stress principle.

While there have been a great number of theoretical/phonological approaches to ambisyllabicity as shown in the above, there are very few empirical studies. Fallows (1981) first conducted an experiment to find out psychological evidence for ambisyllabicity. In her experiment, participants repeated disyllabic words by doubling the first and the second syllables respectively when the interviewer uttered them first, for instance, *o-over* and *over-ver* for the word *over*. In addition to doubling syllables, the participants were asked to make a pause between syllables, for example, '*o-ver*.' Results showed that the intervocalic consonants belonged to both first and second syllables like ambisyllabic consonants in only 22 percent of the tokens. What seemed to be worthy noting was that intervocalic sonorants such as nasals and liquids behaved as ambisyllabic consonants in a higher number (47%) than obstruents. For example, in the case of *summer*, it was repeated in the way of *sʌm-sʌməɹ* and *sʌməɹ-məɹ*. As for pausing between syllables, it was split by pause like *sʌm-məɹ*. This was not, however, above the chance level, roughly indicating the absence of ambisyllabicity. Thus, Fallows (1981) concluded that ambisyllabicity may be merely a syllabification strategy to satisfy both the Onset Maximization Principle and the Weight-Stress principle.

There seem to be, however, some drawbacks in Fallow's study. First, as Treiman and Danis (1988) pointed out, the orthography was not taken into account in her experiment. It might be plausible that double spelled consonants were more likely to be ambisyllabic as the participants used their orthographical knowledge, for example, in *summer* or *silly*. Thus, the question remains unanswered as to whether the higher percent of occurrence of ambisllabicity in liquids and nasals is due to their double spelling. Second, the participants may have been under different stages of linguistic competence because of the difference in the age of participants. They were all young kids who were four to five and nine to ten years old. However, two groups of kids are in different stages of phonological development. According to Ingram (1976), children go through five stages of phonological development. Based on his distinction, children aged four to five are on the third or the fourth stage while children aged nine to ten already passed all of the five stages. This might have distorted the results because the children on the third stage of phonological development had not acquired all the phonological rules as those aged nine to ten. Third, she did not provide any statistical analyses other than the percentage of each category. Therefore, her claim is not entirely reliable.

Treiman and Danis (1988) reported another psychological experiment similar to Fallows (1981). They carried out both oral and writing tasks where subjects were asked to say and write disyllabic words, reversing the syllables as in the example of /mən lɛm/ for *lemon*. Results showed that ambisyllabic consonants appeared to belong to both coda and onset of a syllable, but that intervocalic obstruents were more likely to be onsets than sonorants.

However, their metalinguistic experiment has been questioned recently. As recognized also by the authors themselves, the orthography might have influenced participants' perception in both tasks (Derwing 1992; Elzinga and Eddington 2014). Futhermore, participants would have trouble in word-edge and morpheme-edge judgment (Steriade 1999; Harris 2004, 2006). For example, since English does not allow for stressed lax vowels at the end of a word, subjects in the experiment would have felt awkward when saying 'lemon' as /mən lɛ/. Thus, the majority of them would have produced /mən lɛm/ instead of /mən lɛ/.

Durvasula and Huang (2017) examined the acoustic properties of multiply-linked ambisyllabic consonants, measuring their vowel nasalization and voiced obstruent devoicing and compared them with those of single-linked consonants in onset and coda positions. They assumed that nasals in coda position would be more overlapped with the preceding vowel than nasals in onset position, following Krakow (1989, 1999). They also assumed that voiced obstruents would be somewhat devoiced in the coda position in German accented English such as Pennsylvania Dutchified English (PDE). They found that vowels were more nasalized before ambisyllabic nasals than non-ambisyllabic nasals and that devoicing occurred more in ambisyllabic voiced obstruents rather than non-ambisyllabic consonants. They contended that these served as evidence that ambisyllabic consonants are coda.

Some questions, however, arise in Durvasula and Huang's study. They stated that vowel nasalization was measured through capturing the sudden appearance of strong formant structure and a substantial increase in intensity in the waveform. These configurations were not, however, presented as clearly as stated in the figures. Moreover, using special equipment designed for measuring nasality would have provided rather direct evidence. In addition, the German accented sound stimuli (Pennsylvania District English, PDE) that they used for measuring devoicing were a mere dialect of American English; therefore, their findings cannot be generalized as a common pattern of obstruent devoicing for American English.

Rosalsky (2017) investigated a temporal aspect of ambisyllabic consonants, comparing the duration of ambisyllabic consonants with that of non-ambisyllabic but intervocalic consonants. In her experiment, participants were asked to read nonce words which are composed of a CVC root followed by either a VC or CVC suffix. Results showed that intervocalic consonants, whether ambisyllabic or not, were not significantly different from each other in their duration. They were all shorter than the onset consonants of following syllables when the preceding syllable has a coda. What seemed to matter in the results is that the coda of the preceeding syllable caused the following onset consonant to last longer. Her results seem to be consistent with the phonological analysis about ambisyllabicity that an ambisyllabic consonant is associated with a single mora even though it is multiply-linked to both onset and coda.

Though quite a number of studies attempted to find empirical evidence for ambisyllabicity, their conclusions were not consistent enough, probably due to different methodologies and/or measurements. Ambisyllabic consonants were not psychologically processed as the ones belonging to both coda and onset (Fallows 1981) as opposed to Treiman and Danis (1988). Phonetic, more specifically acoustic, approaches demonstrated contradictive assertions that ambisyllabic consonants patterned with coda (Durvasula and Huang 2017) or with onset (Rosalsky 2017). This sheds light on the current work where phonetic substance of ambisyllabicity is explored. If an ambisyllabic consonant belongs to both coda and onset as asserted in phonology, its phonetic realization is expected to contain dual allophonic variations of both coda and onset. It seems to be, therefore, very important to examine a consonant which shows a very clear phonetic/allophonic distinction between its coda and onset manifestations. The lateral consonant /l/ in English was examined in this study due to the fact that its allophones are widely considered to be acoustically distinctive according to the syllable position; clear-[l] in onset and dark-[ɫ] in coda. On the other hand, for the temporal aspect of ambisyllabicity, not only liquids but also obstruents and nasals were examined. Both spectral and temporal properties of ambisyllabic consonants were compared with those of non-ambisyllabic consonants in an attempt to answer the question of whether ambisyllabic consonants phonetically have dual properties of both onset and coda or a single property of either onset or coda.

3. Hypotheses

As demonstrated in numerous phonological studies, ambisyllabic consonants are associated with both coda and onset, but temporally they are linked to merely one mora. Intervocalic but non-ambisyllabic consonants are all associated with the onset of the following syllable because the vowels of the preceding syllable are all [+tense] and suffice the heaviness of a stressed syllable without a coda consonant. The non-ambisyllabic consonants which are the onset of the following syllable are also associated with one mora, temporally identical to the ambisyllabic consonants. If the phonological structure of ambisyllabic consonants presented in Figure 1 (b) still holds true in actual speech and/or phonetics, their duration is predicted to be statistically similar to that of non-ambisyllabic consonants or syllable-initial or final single consonants.

On the other hand, as shown in psychological studies of Fallows (1981) and Teriman and Danis (1988), the intervocalic ambisyllabic consonants were uttered twice, once as an onset and once as a coda. For example, many of ambisyllabic consonants were repeated like *sum-summer* and *summer-mer* (Fallows) and reversed like *mer-sum*. yet more cases occurred when they were double letters or sonorants. This might be interpreted as stating that the ambisyllabic consonants would be longer than one mora and split into two different moras not only psychologically but also phonetically. If this also hold true in actual speech and/or phonetics, ambisyllabic consonants are predicted to be longer than non-ambisyllabic consonants or syllable-initial or final single consonants. The currents study will, therefore, present phonetic evidence about which approach, phonological or psychological, is appropriate.

For the spectral investigation of amybisyllabicity, F1 and F2 values of the lateral of /l/ were measured in this study. If the phonological structure shown in Figure 1 (b) also holds true in actual speech or phonetically substantial, ambisyllabic /l/ is predicted to have both properties of clear-[l] and dark-[ɫ].

4. Experiment

4.1 Participants

Twelve native English speakers from America or Canada participated in this speech production experiment. All of them were college students except two graduate students. Seven of them were female, and the other five were male. Their background information is presented in Table 1.

Table 1. Participants' background information

Participants	State	Country	Gender	Age
speaker 1	Michigan	U.S.A.	M	27
speaker 2	Florida	U.S.A.	F	20
speaker 3	Utah	U.S.A.	F	18
speaker 4	Alberta	Canada	M	21
speaker 5	Alberta	Canada	M	21
speaker 6	Minnesota	U.S.A.	F	25
speaker 7	Alberta	Canada	F	28
speaker 8	Missouri	U.S.A.	F	20
speaker 9	Maryland	U.S.A.	M	26
speaker 10	Virginia	U.S.A.	F	22
speaker 11	California	U.S.A.	F	22
speaker 12	Colorado	U.S.A.	M	26

4.2 Stimuli

There were two types of stimuli used in this experiment: one type was disyllabic real words where the intervocalic consonants are ambisyllabic (V_1[lax]+C+V_2) and the other type was those with intervocalic but non-ambisyllabic consonants (V_1[tense]+C+V_2). The intervocalic consonants were varied with obstruents, liquids and nasals. The obstruents included fricatives /f/ and /v/, stops /p, t, k, b, d, g/, and affricates /ʧ, ʤ/, the liquids were /l/ and /r/, and the nasals were /m/ and /n/. Thirteen words were prepared for each segment in both ambisyllabic and nonambisyllabic conditions and 364 words in total were used as stimuli (14 segments * 13 words * 2 conditions = 364 words).

In addition, 13 monosyllabic words beginning with a clear-[l] and ending with a dark-[ɫ] were respectively included fin order to compare them with intervocalic ambisyllabic and nonambisyllabic consonants. There were, in total, 390 tokens (364 disyllabic tokens + 26 monosyllabic words having liquids) in the stimuli. There were also 108 distracter words included, but they were not analyzed. As a result, sound stimuli obtained from recordings were 4698 (390 * 12 subjects), but the tokens actually measured were 4632 because the acoustic displays were blurry in some tokens and they were not able to be measured. Some of the recording stimuli are presented in Table 2.

Table 2. Part of the recording stimuli

segments	non-ambisyllabic stimuli	ambisyllabic stimuli
f	awful, sofa	laughing, differ
v	flavor, even	river, level
p	paper, people	rapid, happy
b	global, Robin	cabin, ribbon
t	daughter, fighter	critic, matter
d	radio, body	radish, pedal
k	bacon, equal	chicken, liquid
g	bagel, legal	figure, wagon
ʧ	coaching, mutual	kitchen, Richard
ʤ	major, region	budget, magic
l	pilot, foolish	color, fellow
r	Irish, sorry	carrot, arrow
m	famous, human	lemon, summer
n	final, donor	many, finish

4.3 Procedure

Recordings were carried out on a recorder (TASCAM HD-P2) with a microphone (Shure 10) in a sound-attenuated booth. Participants agreed to being an experiment subject and signed it before starting to record. They were instructed to read carrier sentences that contain a target word "Please, say __________ for me." on paper. As mentioned above, there were 108 distracters, and the target words and the distracters were randomized with using the randomizing order function in Excel. There were forty sentences listed in one page, with every ten sentences marked by more space, simply to prevent the participants from being lost. They were asked to read them at their normal speech rate. It took about ten to fifteen minutes for them to complete reading all the stimuli.

Two different measurements were executed in spectrograms with a reference to waveforms: for a temporal analysis, the duration of all the intervocalic consonants was measured, and for a spectral analysis, F1 and F2 values of the lateral /l/s were measured. More specifically, the length of both ambisyllabic and non-ambisyllabic consonants was measured to see if there would be any temporal differences between them as the dual linkage of ambisyllabic consonants might result in longer duration than the single linkage of non-ambisyllabic consonants. The raw data were all normalized to remove any possible differences induced from different speech rates among speakers, if any, although they were asked to read the sentences in a casual speed.[1]

Concerning the spectral measurements of the lateral /l/, F1 and F2 values were measured at three different positions (initial, mid, and final points) to keep tracking the tongue movement during the entire production of the laterals. To determine the allophonic variations between clear-[l] and dark- [ɫ], F2 minus F1 (F2-F1) values were calculated, following Ladefoged et al. (1998) and Nance (2014). As generally recognized, dark or velarized [ɫ] is manifested with higher F1 and lower F2 while clear or palatalized [l] is manifested with lower F1 and higher F2. When F2 is subtracted by F1, the distinction between clear-[l] and dark-[ɫ] will be maximized. As the values of F2-F1 increase, the laterals become more likely to be clear [l]. All the measurement data were submitted to statistical analyses such as one-way anova test and T-test in R (V.3.5.0).

4.4 Results

4.4.1 Temporal aspect

The Welch Two Sample t-test was conducted to see if the durations between ambisyllabic and non-ambisyllabic intervocalic consonants of all target segments would be similar or different. Results showed that the two groups have no significant difference in duration with the mean values of 33.134ms for ambisyllabic consonants and 33.888ms for non-ambisyllabic consonants (t=-0.899, df=2135.3, p=0.369) as represented in Figure 3.

1 The duration of an intervocalic consonant was normalized in such a way that it was divided by the duration of the word 'say' in the same utterance 'Please say _______ for me.' Otherwise, the raw data would be affected by individual speakers' speech rate. It was then multiplied by 100 because there were too many places of decimals.

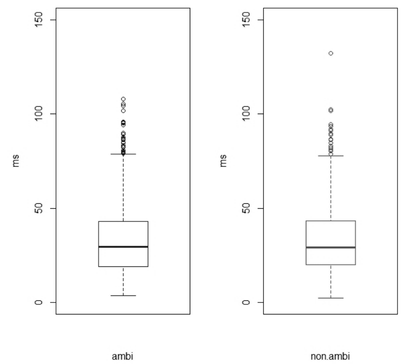

Figure 3. Durations of ambisyllabic and non-ambisyllabic intervocalic consonants

Treiman and Danis (1988) demonstrated that obstruents did not pattern with liquids or nasals in their psychological experiment. Obstruent consonants did not behave as dual linking with both onset and coda while liquids and nasals did. Along the same line, the duration results will be divided into three categories (obstruents, liquids and nasals) and discussed separately now. According to the Welch Two Sample t-test results, there is no significant difference in duration between ambisyllabic obstruents and non-ambisyllabic intervocalic obstruents ($t=-1.007$, $df=1524.6$, $p=0.314$). The mean values for each group are 35.741ms and 36.844ms respectively as shown in Figure 4.

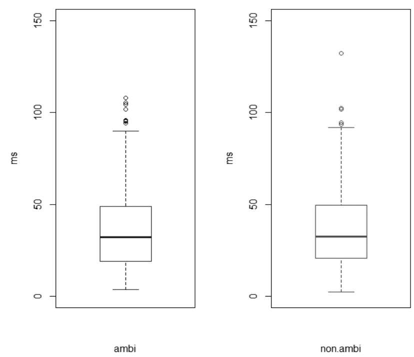

Figure 4. Durations between ambisyllabic and non-ambisyllabic intervocalic obstruents

Like obstruents, ambisyllabic nasals and non-ambisyllabic intervocalic nasals are not significantly different in duration with the mean values of 26.498ms for ambisyllabic nasals and 25.121ms for non-ambisyllabic nasals (t=1.119, df=307.77, p=0.264) as shown in Figure 5.

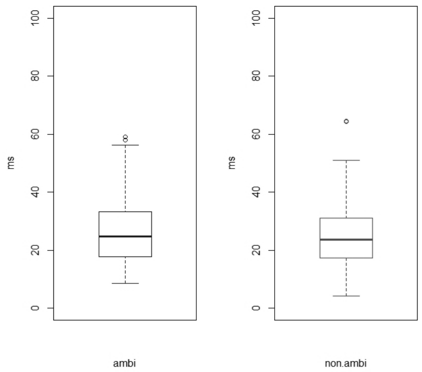

Figure 5. Durations between ambisyllabic and non-ambisyllabic intervocalic nasals

Intervocalic liquids, whether they are ambisyllabic or non-ambisyllabic, showed no significant difference in duration (t=-1.004, df=299.49, p=0.316). The mean values are 26.777ms for ambisyllabic liquids and 27.875ms for non-ambisyllabic liquids as illustrated in Figure 5.

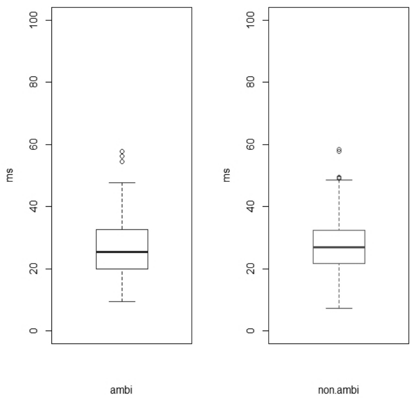

Figure 6. Durations between ambisyllabic and non-ambisyllabic intervocalic liquids

4.4.2 Spectral aspect

It is very well known that the English lateral /l/ has two distinctive allophones according to syllable position. Their articulation is dramatically different; clear-[l] is produced in the front of the vocal tract whereas dark-[ɫ] is in the back. Such articulatory configurations are acoustically implemented as similar F1 and F2 formant values to the vowels /i/ and /u/. Assuming that F2-F1 values are an indicator for clear -[l] and dark-[ɫ] (Ladefoged et al. 1998; Nance 2014), the F2 values were subtracted from those of F1, and the data were statistically analyzed with using R.

In the one-way ANOVA test, four groups of laterals were independent variables: ambisyllabic /l/, non-ambisyllabic intervocalic /l/, clear-[l] in monosyllabic onset position, and dark-[ɫ] in monosyllabic coda position. The test was executed to see which of onset or coda the ambisyllabic or non-ambisyllabic laterals are statistically similar or different. Results showed that the four groups of laterals were significantly different at all three timing points such as initial, mid, and final points of the laterals ($F=23.25$, $p<0.001$ for initial point, $F=41.38$, $p<0.001$ for mid point and $F=32.68$, $p<0.001$ for final point. The statistical results are graphically presented in Figure 7. In order to observe the differences among the groups, the TukeyHSD test was carried out. The post-hoc results showed that the ambisyllabic /l/ and the non-ambisyllabic intervocalic /l/ seem to be significantly similar to each other ($p=0.871$) at the beginning of lateral production as in Figure (a). However, both of them were significantly different from clear-[l] and dark-[ɫ] ($p<0.001$). Not surprisingly, clear-[l] and dark-[ɫ] also showed a significant difference ($p<0.001$). Such results were not observed only at the mid point but also at the end of lateral articulation. As for the mid point, ambisyllabic and non-ambisyllabic /l/ sounds seemed to be almost identical to each other ($p=0.999$). The ambisyllabic lateral /l/ is different from both clear-[l] and dark-[ɫ] ($p<0.001$ for both), so was the non-ambisyllabic lateral /l/ ($p<0.001$). This is shown in Figure 7 (b). Clear-[l] and dark-[ɫ] were, as expected, significantly different each other in the midpoint ($p<0.001$). Ambisyllabic and non-ambisyllabic /l/s were not significantly different from each other ($p=0.984$) at the end of lateral, and both of them were significantly distinctive from clear and dark /l/s (p=<0.001) as shown in Figure 7 (c).

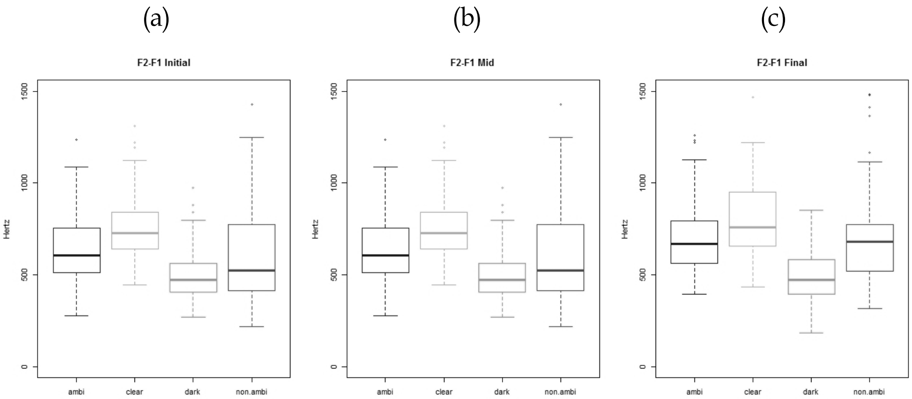

Figure 7. F2-F1 values of four different /l/s at three timing points of lateral articulation (initial, mid and final points)

4.5 Discussion

Ambisyllabicity has been long discussed in Phonology, but only a few studies have investigated its phonetic substantiality. Psychological experiments could not answer the question about how differently and/or similarly ambisyllabic and non-ambisyllabic consonants are phonetically manifested. They merely interpreted the results from cognitive perspectives. The findings presented in recent phonetic studies were also inconsistent. Durvasula and Huang (2017) suggested that ambisyllabic consonants were more likely coda based on the results of vowel nasalization and devoicing. However, Rosalsky (2017) concluded that ambisyllabic consonants patterned with onset. The current study has evaluated the temporal and spectral properties of ambisyllabic consonants in comparison with non-ambisyllabic intervocalic consonants as well as word-initial onsets and word-final codas.

The temporal properties of ambisyllabic consonants were very similar to those of non-ambisyllabic consonants in all three categories of obstruents, liquids and nasals. This is consistent with the phonological analysis that an ambisyllabic consonant is associated to a single mora in its syllable structure though it branches to both the onset of the preceding syllable and the coda of the following syllable.

Looking back the results of the spectral characteristics of intervocalic ambisyllabic and non-ambisyllabic laterals, it turned out that neither of them was clear-[l] or dark-[ɫ]. Non-ambisyllabic laterals were expected to show the clear-[l] properties as it is syllabified into the onset of the following syllable according to the Onset Maximization Principle in Phonology. However, the F2-F1 values of non-ambisyllabic laterals were significantly different from those of clear-[l] or dark-[ɫ]. This indicates that the phonological analysis is not phonetically supported.

When ambisyllabic laterals are concerned, their F2-F1 values showed significant differences from those of clear-[l] or dark-[ɫ] like non-ambisyllabic laterals. They were expected to show the acoustic features of both clear and dark /l/s as they are syllabified into both the coda of the preceding syllable and the onset of the following syllable in Phonology. That is, their F2-F1 values were predicted to be statistically not different from those of clear-[l] or dark-[ɫ]; that is, they would be supposedly overlapped with both clear and dark /l/s to some degree. However, it turned out that they did not share any spectral properties with either clear-[l] or dark-[ɫ]. The phonological analysis is, again, not phonetically supported.

Both ambisyllabic and non-ambisyllabic intervocalic laterals turned out to be very similar acoustically at three different timing points (at the beginning, in the middle and at the end of lateral production). What was worthy noting here is that their F2-F1 values were consistently in between those of clear-[l] and dark-[ɫ] as presented in Figure 7. This suggests that acoustically they should belong to other allophony than clear-[l] or dark-[ɫ]. How do we then interpret such results in the articulatory dimension? Are they *hypothetically* produced with both articulatory configurations of clear-[l] and dark-[ɫ] at the same time? It should be almost impossible that the front of the tongue contacts the alveolar ridge to articulate clear-[l] and simultaneously the back of the tongue retracts backward to articulate dark-[ɫ]. Since their F2-F1 values were higher than of dark-[ɫ] and lower than that of clear-[l], the intervocalic laterals, whether ambisyllabic and non-ambisyllabic, may be articulated with the back of the tongue less retracting and the front of the tongue contacting a slightly backer area than the alveolar ridge. That is, either clear or dark /l/ does not successfully achieve its articulatory target gesture. Therefore, a new allophone of the lateral /l/ will emerge in intervocalic position, and it should be represented with a dual linkage to both coda of the preceding syllable and onset of the following syllable consistently to phonetic manifestation.

A question may be brought up now; why are non-ambisyllabic intervocalic laterals not realized as onset of the following syllable acoustically? Onset priority is a universal pattern found in many languages; thus, it should be merely similar to a monosyllabic onset lateral for F2-F1 values. It could be stipulated that it is presumably an onset of the following syllable but that the preceding stressed vowel, hyperarticulated enough, will make more bondage with the following intervocalic lateral. Such solidarity between a stressed vowel and the following consonant occurs whether the vowel is tense or lax because ambisyllabic laterals in which the preceding vowel is stressed but lax also showed no difference from non-ambisyllabic laterals. What seems to contribute to making both of them dual properties is stress rather than their ambisyllabicity. Intervocalic laterals may be, whether it is phonologically ambisyllabic or not, articulated with both the front and the back of the tongue involved, though their target gestures may go through undershoot to some degree. What might happen to intervocalic laterals in bisyllabic words where stress goes to the following syllable, for instance, /əlajk/ 'alike'? If it is true that stress plays a role in determining the properties of intervocalic laterals, the /l/ sound in /əlajk/ is predicted to be statistically not different from clear-[l]. That is, it will be acknowledged as onset of the following syllable due to the onset priority, and the onset status might be strengthened by the bondage induced from the hyperarticulation of the stressed vowel /aj/ in the following syllable. Definitely a phonetic examination should be done for intervocalic laterals in the words with stress on the following syllable.

5. Conclusion

Phonologically ambisyllabic consonants have been investigated temporally and spectrally and compared with non-ambisyllabic intervocalic consonants. Both are not significantly different: durations of both consonants are similar and F2-F1 values of laterals are also similar. Therefore, ambisyllabicity is not peculiar to a special intervocalic consonant which is preceded by a stressed lax vowel. Any intervocalic consonants have dual properties of onset and coda when the preceding syllable is stressed whether it has a tense or lax vowel.

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