TEMPORAL ORGANIZATION OF WORD-INITIAL CONSONANT SEQUENCES IN NAJDI ARABIC

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ABSTRACT

This study investigated the syllabic affiliations of Najdi Arabic word-initial consonant sequences (#CC), by examining the temporal relation among segments using acoustic measures. Using minimal pairs: #C_1C_2VX vs. #C_2VX produced by Eight Najdi Arabic speakers, two intervals were compared: C-CENTER (from the mean of the midpoint(s) of C(s) to V offset) and RIGHT-EDGE (from the release of immediately prevocalic C to V offset). Results demonstrated RIGHT-EDGE stability. While C-CENTER was significantly longer in #CCVX than in #CVX, RIGHT-EDGE was not. Additionally, the durational variance was smaller in RIGHT-EDGE than in C-CENTER. These suggest #CC is heterosyllbically parsed in Najdi Arabic, corroborating the claim that Najdi Arabic is restricted regarding word-initial tautosyllabic clusters. Najdi Arabic may not allow word-initial tautosyllabic consonant clusters.

Keywords: Najdi Arabic, Syllable, Word-initial Consonant Sequence, Temporal Organization.

1. INTRODUCTION

1.1. Background

Syllabic parsing of word-initial consonant sequences can be informed by the component consonants' temporal patterns (e.g., [1, 2]). Syllable onset consonants are temporally coordinated with the rest of the syllable such as the rime. That is, when a word-initial sequence of multiple consonants forms a tautosyllabic onset cluster (i.e., #CCVX), all component consonants are temporally coordinated relative to the rime. On the other hand, when a sequence of consonants is heterosyllabically parsed (i.e., #C.CVX), the consonant(s) not forming the syllabic onset would not have a stable temporal relation with the rime.

The relation between the syllabic organization and the temporal patterns has been examined in different languages. For example, English has been claimed to have complex onsets, or onset clusters, because the intervals between the c-center (the mean of the midpoints of each consonant in consonant sequences) to the anchor (the end of the syllabic nucleus) is more stable than those between the right-edge (the release of the immediately prevocalic consonant) to the same anchor (e.g., [1]). The c-center to anchor interval remains stable because each consonant in the consonant sequence is coordinated with the rest of the syllable structure. On the other hand, if the right-edge to anchor interval is more stable than the c-center to anchor interval, it suggests that only the rightmost consonant in the sequence forms the syllabic onset with the preceding consonant(s) being parsed heterosyllabically (i.e., #C.CVX). This pattern has been reported in Moroccan Arabic [3, 4], Tashlhiyt Berber [5], and Jazani Arabic [6].

While most of these previous studies [1, 2, 3, 4, 5] rely on articulatory measures to investigate these temporal patterns, acoustic measures have also been shown to exhibit consistent temporal patterns in [6], opening the possibility of using acoustic measures to examine syllabic affiliations of consonant sequences.

1.2. Current Study

This study investigates the syllabic affiliations of Najdi Arabic word-initial consonant sequences (#CC) using acoustic measures. Najdi, an understudied variety of Arabic spoken mainly in the center of Saudi Arabia, has been described as having onset consonant clusters (e.g., [7]). However, the temporal patterns of the component consonants have not yet been examined.

It has recently been claimed that Najdi may be very limited in terms of onset consonant clusters, based on Najdi speakers' production patterns [8]. Najdi speakers in [8] produce prothetic vowels before word-initial C_1C_2 when C_1 is more sonorous than, or as sonorous as, C_2. That is, #CCVX with a falling or plateau sonority profile are realized as [#vC.CVX] while those with a rising sonority profile would surface as [#CCVX]. These findings, according to [8], provide evidence that Najdi allows only the onset clusters with a rising sonority profile but prohibits those with a less preferred sonority profile, consistent with the predictions of the Sonority Sequencing Principle (e.g., [9, 10, 11]). However, it remains unclear if Najdi #CC sequences surfacing without a prothetic vowel are tautosyllabic onset clusters.

The present study aims to determine the syllabic affiliations of the component consonants of Najdi #CC sequences with rising sonority profiles. To that end, we investigate the temporal patterns of consonant sequences that surface with no simplifications (i.e., a vowel prothesis) to determine whether their syllabification is tautosyllabic [#CCVX] or heterosyllabic [#C.CVX]. The main research question of this study is the following: When word-initial consonant sequences surface without prothesis in Najdi Arabic, are they parsed as tautosyllabic CC onset clusters?

2. METHODS

2.1. Participants

Eight native speakers (3F, 5M, mean age = 26) of Najdi Arabic, from the central part of Saudi Arabia (Riyadh and surrounding towns), participated in the study in Az-Zulfi, Saudi Arabia. They all reported speaking the Modern Standard Arabic, but no other dialects of Arabic. The participants also reported speaking English as the second language.

2.2. Stimuli

The stimuli, shown in Table 1, consisted of seven minimal pairs differing in the number of initial consonants: #C_1C_2VX vs. #C_2VX.

#C_1C_2VX	Gloss	#C_2VX	Gloss
ʃbuk	fences	buk	wallet
bzur	children	zur	fake
ʃmus	very hot	mus	razor
snun	teeth	nun	letter “N”
dru:s	lessons	ru:s	heads
flan	someone	lan	become soft
ħraseh	protecting	raseh	his head

Table 1: 14 target words in the stimuli

All #C_1C_2 sequences were of rising sonority profile with varying sonority distances between C_1 and C_2. The current study adopts the scale proposed by Gouskova [12] for its thorough display of the categories.

2.3. Tasks and Procedures

The participants produced the target words embedded in two different carrier phrases. In one of the carrier phrases, the target word was preceded by a vowel /i/ (e.g., [haði ___ mar:ah] “This is ___ once.”), and in the other one, by a consonant /k/ (e.g., [ðik ___ mar:ah] “That is ___ once.”). These carrier phrases were used to examine if the preceding segment would influence the syllabification. A preceding vowel can possibly promote a heterosyllabic parsing of #CCVX (e.g., [ði#C.CVX]) compared to a preceding consonant (e.g., [ðik.#CCVX]).

Each speaker repeated the target words 7 times in each carrier phrase, and their speech was acoustically recorded.

2.4. Measurements and Analysis

To determine the syllabification of consonant sequences, we used acoustic measures that were similar to the ones used by previous studies (e.g., [3, 4, 6]). Each target word #(C_1)C_2VX yielded three acoustic landmarks: c-center (the mean of acoustically measured midpoints of C_1 and C_2), right-edge (the acoustic release of C_2) and the anchor (the acoustic onset of postvocalic X). From these landmarks, we obtained two interval measures: c-center to anchor (henceforth C-CENTER) and right-edge to anchor (henceforth RIGHT-EDGE).

The two interval measures, C-CENTER and RIGHT-EDGE, were then examined to determine which was more stable. The stability was determined based on two different analyses. First, duration analysis compared the interval measures between #CCVX and #CVX words. If an interval measure remains constant when a consonant is added, it is considered stable. For example, if /dru:s/ and /ru:s/ are more similar in their C-CENTER measures than in the RIGHT-EDGE measures, C-CENTER is considered to be more stable than RIGHT-EDGE. Second, variance analysis compared the durational variances of the two interval measures, using the relative standard deviation (RSD). The interval measure with smaller durational variances is considered to be more stable. The RSD is more conservative measure than the more commonly used standard deviation in our case, as it is less inclined toward the RIGHT-EDGE stability (see [3, 4] for more information on RSD calculation).

For annotation, the boundaries for words and segments were initially determined using the Montreal forced aligner [13], and then hand-corrected in Praat [14].

2.5. Predictions

The most stable interval would indicate the syllabification of the word-initial CC sequences in Najdi Arabic. If #CC sequences are tautosyllabic and form true onset clusters (e.g., [7]), it is predicted that C-CENTER would be more stable than RIGHT-EDGE. On the other hand, if Najdi #CC sequences are heterosyllabically parsed (#C.CVX), as suggested in [8], RIGHT-EDGE is predicted to be more stable than C-CENTER.

3. RESULTS

3.1. Duration analysis

Figure 1 shows the difference between C-CENTER and RIGHT-EDGE measures across #CCVX and #CVX words. The mean C-CENTER interval was 229.2 ms for #CCVX and 185.2 ms for #CVX, while the mean RIGHT-EDGE interval was 140.5 ms for #CCVX and 142.2 ms for #CVX.

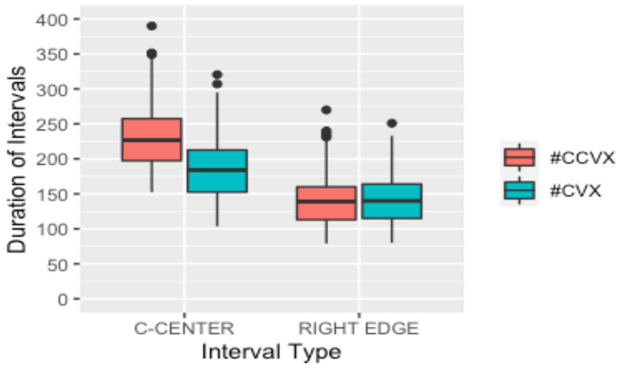

Figure 1: C-CENTER vs. RIGHT-EDGE by word size

To examine if the observed differences in duration are statistically significant, two logit mixed-effects model analyses [15] were performed in R [16] with the lme4 package [17], one for C-CENTER and the other for RIGHT-EDGE. The dependent variable for these models was the respective interval (C-CENTER vs. RIGHT-EDGE). Each model included word size (#CCVX vs. #CVX) and environment ("target preceded by a consonant" vs. "target preceded by a vowel"), and their interactions as fixed effects. The factors were contrast coded. Participants and items were included as random effects with by-items random slopes for environment. Including more random slopes led to convergence errors. P-values were obtained by comparing the full models with the models without the effects in question.

Model comparisons for C-CENTER revealed a significant effect of word size [$\chi^2(1) = 14.48$, $p < .001$]: #CCVX were longer than #CVX. However, environment [$\chi^2(1) = .002$, $p = .97$] and the interaction between environment and word size [$\chi^2(1) = 1.02$, $p = .31$] were not significant. These outcomes suggest the C-CENTER duration was influenced by word size, not the environment or the interaction between word size and environment. The duration of C-CENTER was significantly longer in #CCVX than #CVX, across the environments (i.e., carrier phrases).

Model comparisons for the RIGHT-EDGE models revealed that none of the fixed effects or their interaction contributed significantly to the model fit. The effects of word size [$\chi^2(1) = .12$, $p = .73$], environment [$\chi^2(1) = .18$, $p = .67$], and their interaction [$\chi^2(1) = 0$, $p = .99$] were not significant. These outcomes suggest that the RIGHT-EDGE duration was not influenced by the word size or the environment. The #CVX and #CCVX words, regardless of the environment, had similar RIGHT-EDGE interval.

This pattern held across speakers. Figures 2 and 3 show each speaker's C-CENTER and RIGHT-EDGE measures. For all speakers, C-CENTER, but not RIGHT-EDGE, was longer in #CCVX than #CVX. Despite individual differences in their overall interval measures, all speakers showed more stability in RIGHT-EDGE than C-CENTER intervals.

The RIGHT-EDGE stability was sustained across all word pairs, regardless of their sonority distance. Figure 4 shows the RIGHT-EDGE interval duration of #CCVX and #CVX in each pair.

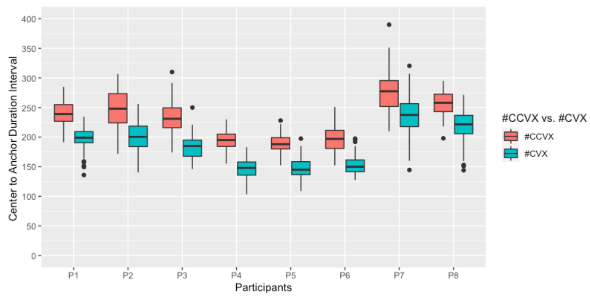

Figure 2: C-CENTER in #CCVX vs. #CVX by speaker

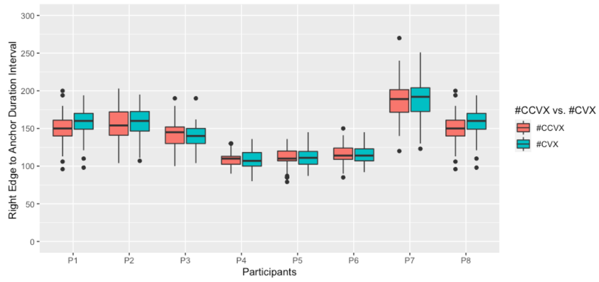

Figure 3: RIGHT-EDGE in #CCVX vs. #CVX by speaker

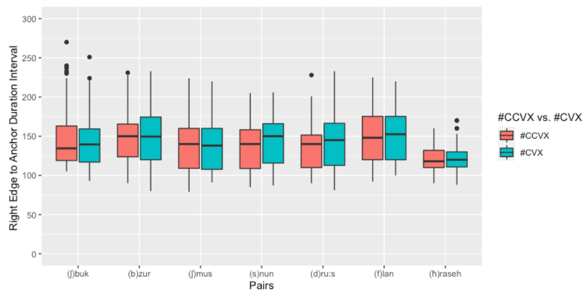

Figure 4: RIGHT-EDGE in #CCVX vs. #CVX by item

3.2. Variance analysis

The relative standard deviation (RSD) was calculated across the two intervals, and then compared using logit mixed-effects model analysis in R [16] with the lme4 package [17]. The dependent variable was the RSD. The predictor was the interval type (C-

CENTER vs. RIGHT-EDGE). Participants and items were included as random effects in the model.

Model comparison revealed a significant effect of the interval type [$\chi^2(1) = -3.92$, $p < .001$]. The RSDs of RIGHT-EDGE were significantly smaller than those of C-CENTER (Figure 5).

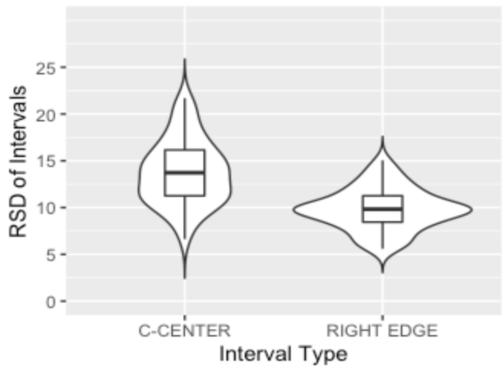

Figure 5: RSD of C-CENTER vs. RIGHT-EDGE

3.3. Summary of findings

The results of the duration analysis and the variance analysis, taken together, suggest that RIGHT-EDGE was more stable than those of C-CENTER. Words of a different size (#CCVX vs. #CVX) had different C-CENTER durations but the RIGHT-EDGE durations remained constant. This pattern was found across all speakers and items examined. In addition, the RIGHT-EDGE intervals had smaller RSD than the C-CENTER intervals.

4. DISCUSSION

Najdi #CC sequences with a rising sonority profile, unlike those with a falling or plateau sonority profile, were reported to surface without vowel insertion [8]. This raised a question if the #CC sequences, not modified by a prothetic vowel, would form a true onset cluster. This study examined the temporal patterns of Najdi word-initial CC sequences with a rising sonority profile to answer this question.

The overall results confirmed that C-CENTER and RIGHT-EDGE were substantially different. RIGHT-EDGE was shown to be not different between #CVX and #CCVX (see Figures 1 and 3), remaining constant regardless of the number of consonants in a sequence. Although individual speakers and word pairs had their own range of RIGHT-EDGE measures (Figures 3 and 4), RIGHT-EDGE stability was found in all speakers and word pairs. On the other hand, C-CENTER was notably less stable and increased as the number of consonants in the sequences increases. This was indicated by that #CCVX had significantly longer C-CENTER than #CVX (Figure 2). Moreover, the results of the variance analysis using RSD established that C-CENTER interval showed a greater variance than RIGHT-EDGE interval (Figure 5). All these outcomes indicated a greater stability in RIGHT-EDGE than in C-CENTER.

Interestingly, these patterns were held constant regardless of whether the preceding segment was a vowel /i/ or a consonant /k/. The preceding segment did not encourage or impede heterosyllabic or tautosyllabic parsing of the #CC sequences.

A greater stability in RIGHT-EDGE than in C-CENTER suggests that Najdi #CC sequences show the temporal patterns more consistent with hetero-syllabic parsing [#C.C] than tautosyllabic parsing [#CC]. Similar to Moroccan Arabic [3, 4] and Jazani Arabic [6], Najdi Arabic appears to have simplex onsets, with #CC sequences being heterosyllabically parsed as [#C.C].

This study relied on acoustically measured landmarks to obtain C-CENTER and RIGHT-EDGE intervals, similar to [6]. The acoustic measures used in the current study did not capture exactly the same information as the articulatory measures used in most previous studies on the temporal organization of consonant sequences (e.g., [1, 2, 3]). Still, the acoustic measures revealed the consistent patterns in both duration and variance analyses, supporting the interpretation that one interval (RIGHT-EDGE) was more stable than the other (C-CENTER). This provides a support to the claim in [6] that acoustic measures can be used to examine syllabic organizations of consonant sequences.

5. CONCLUSION

The current study provides evidence, based on the temporal measures of the #C_2VX and #C_1C_2VX sequences, that #CC in Najdi may not be tautosyllabic consonant clusters even when they surface without a prothetic vowel. Instead, the #CC sequences are likely syllabified as [#C_1.C_2]. As suggested in [8], Najdi Arabic may have an underlying vowel before the consonant sequences /#VC_1.C_2/, which surfaces only when C_1 is more sonorous than, or as sonorous as, C_2. When C_1 is less sonorous than C_2 (i.e., sonority rise), the underlying vowel is deleted in the surface form but the temporal organization of the consonants still show the heterosyllabic parsing.

Our findings suggest that Najdi is the third Arabic dialect that shows the RIGHT-EDGE stability, following Moroccan Arabic [3, 4] and Jazani Arabic [6]. This raises the question of whether there would be other Arabic varieties showing the same pattern, calling for more studies that examine the temporal patterns of word-onset consonant sequences in other Arabic varieties.

6. ACKNOWLEDGMENTS

We would like to give special thanks to Dr. Steven Weinberger, Dr. Ghada Khattab, and Dr. Douglas Wulf for their valuable comments and feedback. Our appreciation extends also to all faculty members and PhD students at the English department—linguistics major—in George Mason University.

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