Repairing Word-External Onsetless Syllables during Late Childhood

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1. Introduction

Cross-linguistically, syllables with onsets (i.e., /CV/) are preferred over syllables without them (i.e., /V/ or /VC/) (Kahn 1976; Selkirk 1982). In word-external position, onsetless syllables appear on the edge of the prosodic word and can be preceded by either a consonant (e.g., an onion) or a vowel (e.g., two onions). In the case of word-external consonant-vowel sequences (i.e., /C#V/), the current view in English phonology is that the onsetless syllables are repaired by means of ambisyllabic consonants, segments that are linked to both the coda and the onset positions. (Kahn, 1976; Rubach, 1996 among others). Ambisyllabic consonants constitute complex syllabic positions as they need a split branching (i.e., one segment attaches to both the coda and the onset positions). To my knowledge, the acquisition of /C#V/ repair strategies remains unexplored.

During the development of single word production, children present non-adultlike phonological processes such as complex cluster reduction, velar or palate-alveolar fronting, and stopping of fricatives or affricates. These processes tend to disappear around the ages of 4-5 (Dodd et al. 2003; Cohen and Anderson 2011; Roberts, Burchinal, and Footo 1990). The development of connected speech, by contrast, has been less studied. However, a few studies suggest that word-external phonological phenomena are mastered during later childhood (see Athanasopoulou [2018] for stress clash strategies, or Nittrouer [1993] for unstressed function words). The question that arises from this literature is thus whether word-external repairs of onsetless syllables (i.e., /C#V/ junctures), which require the acquisition of the complex syllabic structures, are also developed during late childhood (i.e., between the ages of 6 to 10) and at what specific point they reach adultlike production.

2. Strategies to Repair Word-External Onsetless Syllables

Onsetless syllables are repaired in English with ambisyllabic consonants, which appear between two syllabic nuclei and are shared by the onset and coda syllabic representations (Kahn 1976). The existence of ambisyllabic consonants

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is itself supported by the phonological process of English flapping, whereby an underlying t/ behaves differently in intervocalic position (i.e., ambisyllabic, *atom* [ˈæɾom]) than in canonical coda or onset positions. Hence, the flap segment is multiply linked with the coda and the following onset (Kahn, 1976). Ito and Mester (2009) formalize the occurrence of ambisyllabic consonants under a constraint-based approach (Prince and Smolensky 1993, 2004). On this approach, ambisyllabic consonants arise from an interaction between a pair of constraints which respectively require syllabic onsets (i.e., ONSET) and alignment between the left edge of the stem and the left edge of the prosodic word (i.e., ALIGN-LEFT (STEM, ω)) (Ito and Mester 2009, 7). Phonetic and corpus studies on word-external ambisyllabic consonants have introduced glottal phonation as a further repair for onsetless syllables. For instance, Scobbie and Pouplier (2010) found that half of their speakers produced every ambisyllabic token with glottalization. Pak (2016) found that 25% of the adult utterances containing the function word *an* in CHILDES (MacWhinney, 2000) showed glottal phonation (e.g., an[ʔ]éxcellent idea). This raises the possibility of /ʔ/- epenthesis to fill the onsetless syllables. Similarly, Cruttenden (1994: 291) notes that a glottal stop might appear in front of an accented syllable in the presence of emphasis (e.g., [an[ʔ]aim), a claim supported by phonetic studies showing that glottal phonation appears in prosodically prominent positions (e.g., pitch-accented words) (Dilley, Shattuck-Hufnagel, and Ostendorf 1996; Garellek 2013, 2014; Redi and Shattuck-Hufnagel 2001) However, Cruttenden (1994, 291) states that overuse of glottal stops in these positions is more common in L2 English learners than in L1 English speakers. In this paper, I include adult English speakers to establish a baseline rate of /ʔ/-epenthesis.

3. Acquisition of Word-External Repairs of Onsetless Syllables

The ability to produce word-external repairs of onsetless syllables requires the development of split branching representations (i.e., multiple linked consonants), as well as the acquisition of the complete prosodic word. While children acquire the onset position in the first stages of syllabic production, complex onset structures, such as binary branching (i.e., complex onset clusters) are acquired only during later stages of development (Levelt, Schiller, and Levelt 2000; Freitas 2003; Kehoe et al. 2008). In Portuguese, for instance, children undergo an initial stage in which they insert an epenthetic vowel between the two consonants in the complex cluster ([C_1VC_2]) (Freitas 2003). Similarly, Levelt, Schiller and Levelt (2000) found that a markedness constraint against complex onsets and codas (*COMPLEX) remains highly ranked until the penultimate stage of word-internal syllabic development. Like complex onset clusters, ambisyllabic consonants require a split branching, which in this case appears between coda and onset positions. In /C#V/ sequences, moreover, split branching occurs across prosodic words, which requires the acquisition of prosodic word structure. Although /C#V/ junctures have not yet been examined in experimental studies, Newton and Wells (2002) examined /V#V/ junctures in the speech of one child (2;4-3;4). Crucially for the current study, these authors examined production of glide /j w/- and /r/-insertion in /V#V/ cases (e.g., *tidy up* [taɪdiʲʌp]), and found that glottal phonation was used to produce most junctures between the ages of 2;7 and 2;9. The percentage of glide liaison reached adultlike patterns at 2;10, increasing to 80-85%, while /r/-liaison (*painter in* [peɪntəɹɪn]) appeared at the age 2;11, and glottal stops in cases of /r/ liaison were produced until the end of recording (3;4) (*painter in* [peɪntəʔɪn]). In both cases, /ʔ/-insertion preceded adultlike segmental epenthesis (/r/ and /j, w/). /ʔ/-insertion hence appears to be the favored production in word-external junctures during language maturation.

4. Research Questions

My first research question asks whether the production of word-external empty onsets (i.e., /C#V/ sequences) continues to develop between the ages of 6 and 10 years-old. That is, does /ʔ/- epenthesis (i.e., rate of glottal phonation and degree of glottal constriction) prevail in the production of /C#V/ sequences during late childhood?

- Drawing from the evidence for late acquisition of complex syllabic structures, I predict that /C#V/ sequences will show development during late childhood. That is, children will produce word-external empty onsets with a higher rate of /ʔ/-epenthesis and degree of glottal phonation than those of adults.

My second research question asks whether /ʔ/-epenthesis diminishes between the ages of 6 and 10 years-old, and whether any such diminishment can be expected to occur at the same rate across consonants.

- I predict that /ʔ/-epenthesis will diminish during late childhood as repairs of word-external onsets become more adultlike, and that it will do so at the same rate across different consonants.

My third research question asks whether prosodic prominence predicts /ʔ/-epenthesis during late childhood.

- I predict that strong vowels (i.e., vowels with primary stress) will be more often glottalized and will show a higher degree of glottal phonation than weak vowels (i.e., vowels without primary stress).

5. Methods

5.1. Participants

Twenty-four children and eight adults participated in this study. Children were divided into a young group of 6-to-8-year-olds (i.e., children 6-8 henceforth) (7 F, Mean = 7.69 years, *SD* = 0.68) and an older group 9-to-10-year-olds (i.e., children 9-10 henceforth) (5 F, Mean = 9.68 years, *SD* = 0.51). The child participants were recruited at the UCLA Lab School and spoke only English at home. The adult participants (5 F, M = 23.12 years, SD = 5.17) were recruited online and were speakers of American English.

5.2. Task

Eight English vowel-initial words were selected for this experiment. Item frequency was controlled using a corpus of child-directed speech samples from CHILDES (MacWhinney 2000). Words with initial primary stress and words without initial primary stress were matched for frequency. Vowel-initial words were matched with the function words *an, all, this* to elicit the coda conditions /n/, /l/ and /s/. The production task had 24 experimental trials (4 items x 2 stress positions x 3 codas) and 6 training trials (2 stress positions x 3 codas). The experiment was built using PowerPoint and four random orders were created. Each slide contained a support word (e.g., *cookie*) and the target word (e.g., *olive*). The support words were used to construct parallel structures in the elicitation phrases (e.g., *This is a cookie, and this is…*). The elicitation sequences were recorded by a female speaker of American English. The recordings for the child speakers were conducted in a quiet room in the primary school using an AKG C520 head-mounted microphone connected to a Zoom H4n handy portable digital recorder with a sampling rate of 44.1 kHz and a sample size of 16 bits. Adult speech data were collected online using Audacity and an external microphone.

5.3. Coding and Acoustic Measurements

Out of the 768 tokens obtained, 20 were discarded either due to pauses longer than 150ms between the consonant and the vowel, or due to non-target realizations of either the content word or the function word (e.g., *a* for *an*). Results were coded categorically and with continuous measures to examine rate of /ʔ/-epenthesis and degree of glottalization. For the categorical analysis, the tokens were classified as containing modal phonation or glottal phonation (creaky phonation or full glottal stops). Following Davidson and Erker's (2014) study, modal phonation was identified as a constant signal periodicity throughout the /C#V/ sequence (Figure 1, left). Tokens were classified as glottalized if they contained creaky phonation and/or full glottal stops (Figure 1, right). Creaky phonation shows irregularity in the amplitude and duration of the glottal pulses (Redi and Shattuck-Hufnagel 2001; Davidson and Erker 2014).

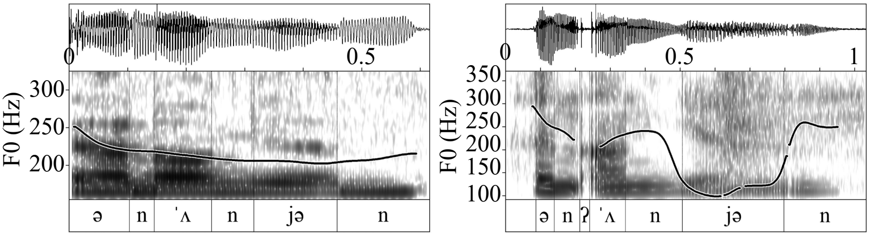

Figure 1. Example of modal phonation (left) and /ʔ/- epenthesis (right)

In order to examine degree of glottal phonation I also extracted Harmonics-to-Noise-Ratio below 500Hz (HNR < 500 HZ), an acoustic correlate of irregular F0 (i.e., creaky voice) that measures spectral noise in the speech signal (Keating, Garellek, and Kreiman 2015). A low HNR (dB) indicates that there is weaker periodicity, and hence more noise in the spectral signal (De Krom 1993), (i.e. stronger degree of glottalization).

6. Results
6.1. Categorical Analysis

For the categorical analysis, I ran a binomial logistic regression with mixed effects (Baayen, Davidson, and Bates 2008) and fitted the model with the glmer() function of the lme4 package (Bates et al. 2015) in R (R Core Team, 2020). Post-hoc pairwise comparisons were conducted using the emmeans package (Lenth, 2020). Variables representing group (i.e., children 6-8, children 9-10, adults), STRESS (i.e., initial primary stress, non-initial primary stress) and consonant (i.e., /s/, /n/, /l/) and their interactions were entered as fixed effects, and variables representing participant and content word were entered as random effects. I compared model fit for random effects using the anova() function. The best fitted model included random intercepts for participant and word. Results (see Figure 2) showed that children 6-8 (i.e., reference level) produced a significantly higher proportion of glottal phonation (M = 71.94%, SE = 2.46%) than adults (M = 42.35% , SE = 3.80%) ($\beta = -3.92$, SE = 1.24, $z = -3.16$, $p < 0.01$). Children 6-8 and children 9-10 (M = 50.61%, SE = 3.21%) did not differ significantly in their rates of glottal phonation ($\beta = -1.91$, SE = 1.15, $z = -1.65$, $p = 0.09$). After releveling the group variable (reference level: children 9-10), children 9-10 and adults did not show a significant difference in their rates of glottal phonation ($\beta = -2.01$, SE = 1.20, $z = -1.67$, $p = 0.09$). The difference between children 6-8 and children 9-10 yielded the same slope as in the previous model ($\beta = -1.91$, SE = 1.15, $z = -1.65$, $p = 0.09$). With regard to stress (reference level: initial primary stress), tokens with initial primary stress were glottalized at a higher rate (M = 79.03% , SE = 2.11%) than tokens without initial primary stress (M = 37.76% , SE = 2.50%) ($\beta = 3.42$, SE = 0.79, $z = 4.29$ $p < 0.01$). For the consonants (reference level: /s/), /s/ showed higher rates of glottalization (M = 61.79%, SE = 3.10%) than /n/ (M = 48.62%, SE = 3.14%) ($\beta = -1.05$, SE = 0.48, $z = -2.20$ $p < 0.01$), but no significant differences were found between /l/ (M = 64.77%, SE = 3.04%) and /s/. Findings also showed a three-way interaction between consonant (i.e., /n/), group (i.e., adults), and stress ($\beta = 3.67$, SE = 1.68, $z = 2.27$ $p < 0.05$), indicating that the relationship between consonant and group ($\beta = 1.84$, SE = 1.09, $z = 1.68$ $p = 0.09$) significantly differed by stress. Visual inspection of the interaction using the function emmip() (Lenth, 2020) and post-hoc analysis showed that the difference in rate of glottal phonation between /n/ and /s/ was larger for adults in syllables without primary stress ($\beta = 2.42$, SE = 0.9, z = 2.68 $p = 0.34$) than for children 6-8 (initial primary stress: $\beta = 0.59$, SE = 0.68, $z = 0.88$ $p = 1$, non-initial primary stress: $\beta = 0.76$, SE = 0.71, $z = 1.06$ $p = 0.99$) or for adults in syllables with primary stress ($\beta = 1.19$, SE = 0.54, $z = 2.18$ $p = 0.76$).

However, the post-hoc analyses did not show significant differences in any of these conditions. I releveled the reference level for consonant (i.e., /l/) to further explore simple effects and interactions and found that /l/ showed significantly higher rates of glottal phonation than /n/ (β = -1.16, SE = 0.49, z = -2.37 $p < 0.01$). With /l/ as a reference level, I replicated the group effect between children 6-8 and adults (β = -2.86, SE = 1.33, z = -2.14, p = 0.03).

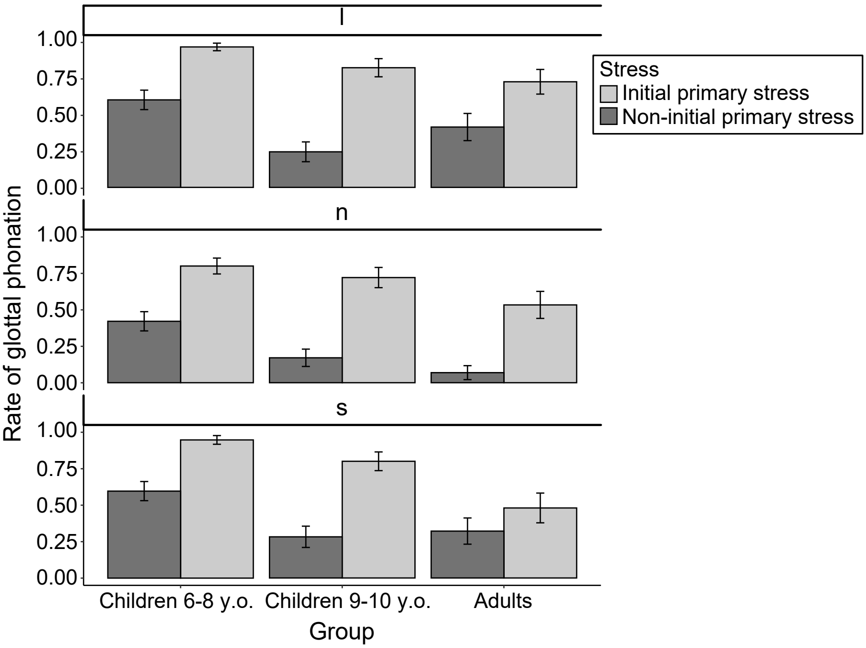

Figure 2. Rate of glottal phonation per group, consonant and stress

6.2. Continuous Analysis

For the continuous analysis (HNR <500 Hz, see Figure 3) I ran a linear mixed effects model (Baayen, Davidson, and Bates 2008) and entered group (i.e., children 6-8, children 9-10, adults), stress (i.e., initial primary stress, non-initial primary stress) and consonant (i.e., /s/, /n/, /l/) variables and their interactions as fixed effects. The best fitted model had random intercepts for the variables participant and word. Results showed that children 6-8 (i.e., reference level) demonstrated lower HNR <500Hz (M = 20.85 dB, SD = 1.07 dB) than adults (M = 31.06 dB, SD = 15.52 dB) (β = 0.65, SE = 0.30, t = 2.12, p =0.04). No significant differences were revealed between children 9-10 (i.e., reference level) and adults. Stress was not found to predict HNR <500Hz. However, an interaction was found between stress and group (children 9-10) (β = -0.9, SE = 0.1, t = -4.52, $p < 0.01$). Post-hoc Tukey tests showed that while children 6-8 did not demonstrate significantly different HNR <500Hz values between syllables with primary stress and syllables without initial primary stress, children 9-10 showed significantly lower HNR <500Hz in syllables with primary stress than in syllables without primary stress (β = 0.59, SE = 0.10, t = 5.84, p < 0.01). With regards to the consonants (reference level: /l/), /l/ was produced with higher HNR <500Hz (M = 23.42 dB , SD = 13.26 dB) than /s/ (M = 20.89 dB, SD = 11.69 dB) (β = -0.34, SE = 0.12, t = -2.76, p < 0.01). An interaction was found between consonant (reference level: /s/) and stress (β = -0.69, SE = 0.19, t = -2.76, p < 0.01). Stress also interacted with consonant (i.e., /n/) (β = -0.67, SE = 0.06, t = -3.52, p < 0.01). Post-hoc analyses indicated that under the condition /n/, syllables with stress (M = 19.98 dB, SD = 12.37 dB) were produced with lower HNR <500Hz values than syllables without primary stress (M = 26.07 dB, SD = 11.32 dB) (β = -0.51, SE = 0.08, t = -6.04, p < 0.01). In addition, /l/ also showed significantly lower values for stressed syllables (M = 20.76 dB, SD = 12.62 dB) than for unstressed syllables (M = 26.05 dB, SD = 13.42 dB) (β = 0.41, SE = 0.10, t = 3.96, p < 0.01). After releveling the consonant factor (reference level: /s/), /n/ showed significantly higher values than /s/ (β = 0.34, SE = 0.12, t = 2.83, p < 0.01). The effect of group (i.e., children 6-8 vs. adults) approached significance with /s/ as the reference level for consonant (β = 0.62, SE = 0.33, t = 1.86, p = 0.06).

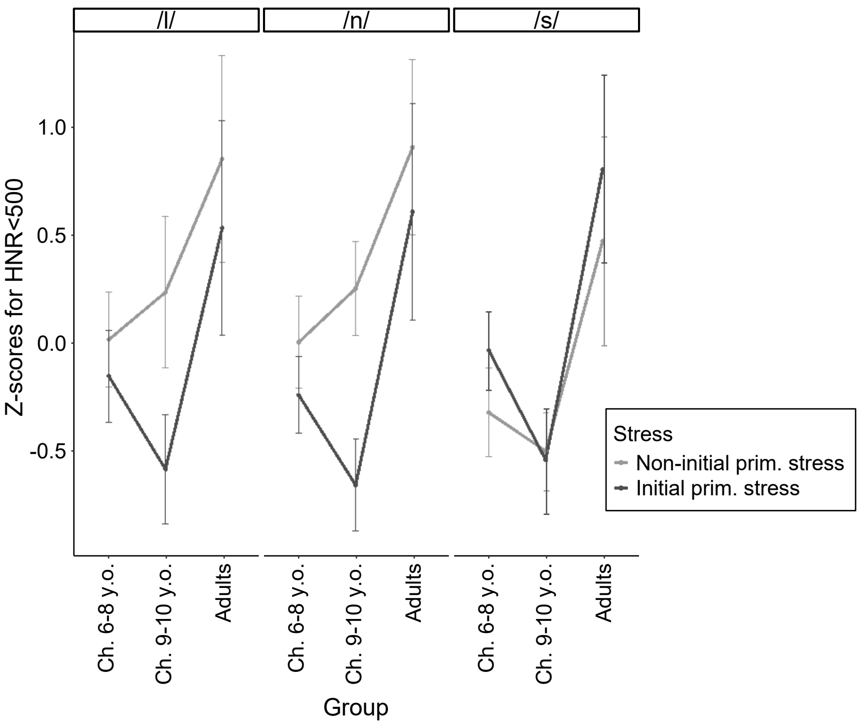

Figure 3. Z-scores for HNR <500Hz per group, consonant and stress

7. Discussion

7.1. Development of Repairs of Onsetless Syllables

The findings of this study show that /C#V/ junctures are still being developed during late childhood. Six-to-eight-year-olds (71.94%) favor /ʔ/-epenthesis over modal phonation and show a significantly higher rate of /ʔ/-epenthesis than that of adults (42.35%). 9-to-10-year-olds (50.61%) do not significantly differ from either group, indicating that they are in an intermediate process of development with a glottal phonation rate falling between younger children and adults. While Newton and Wells' (2002) findings suggest that word-external junctures are acquired during early childhood, my results show that children resort to epenthetic processes also during late childhood. This suggests that word-external misalignments in the syllabic structure are more costly to acquire than between-word epenthetic processes.

Both articulatory maturity and perceptual saliency may explain these results. First, studies on children's articulatory skills suggest that speech gestures are still being mastered past the age of 7 years. Nittrouer (1993), for example, conducted a study on word-external consonant-vowel-stop articulation and found that while vocal tract opening and closing is mastered by age 3 and a half, tongue gestures are constrained at least until the age of 7. More recently, Singh and Singh (2008) examined syllabicity, formant transitions, and place of articulation taking energy distributions in the spectro-temporal modulation profile of children (4-8 years) and adults as a measurement. Their findings showed that while adultlike word-internal syllabicity is acquired by age 4 and formant transitions are evident by age 5, place of articulation signatures do not reach adultlike behaviour until after age 8. In other words, there is a delay in the development of consonant-vowel coarticulatory processes when compared to articulations that do not involve tongue gestures. Glottal stops, by contrast, are produced with an abrupt closure of the vocal folds and do not require movement of the articulators above the larynx (Esling, Fraser, and Harris 2005; Garellek 2013). In addition, the exclusive use of laryngeal articulations during glottal stop production renders glottal stops phonologically transparent to vowel harmony or vowel-vowel coarticulation, because the tongue remains free to adjust to neighboring articulations (Stemberger 1993). This means that /ʔ/-epenthesis does not hinder the acquisition of coarticulation patterns during language development. Ultimately, then, the relative ease of production and phonological transparency of glottal stops can account for my results showing that children resort to /ʔ/-epenthesis to a larger extent than adults.

Another explanation for the preference of glottal phonation is that /ʔ/-epenthesis at word junctures might have perceptual benefits over a misalignment in the syllabic structure. Contrary to syllabic misalignments, that is, glottal phonation strengthens prosodic word boundaries and might facilitate syllabic parsing and lexical access. Evidence for the costs of syllabic misalignment can be found in studies on speech errors. For instance, research on the acquisition of French liaison consonants has found that children make replacement mistakes (e.g., in *le(s)*[n]*éléphants* 'the elephants', production of *[le.ne.le.fɑ] for [le.ze.le.fɑ]) or omission errors (e.g., in *u(n)*[Ø]*éléphant* 'an elephant', production of *[ɛ.e.le.fɑ] for [ɛ.en.le.fɑ]) between the ages of 2 and 6 (Dugua 2006; Chevrot et al. 2013; Chevrot, Nardy, and Barbu 2011). Instances of speech errors involving the production of the coda consonant as the onset of the following word are also attested in Spanish (e.g., in *ojos* 'eyes' production of *[so.xos] for [o.xos]) (D'Introno, Ortiz, and Sosa 1989). While French or Spanish children probably do not use /ʔ/-epenthesis because it is not present in their input, English children might choose to overuse /ʔ/-epenthesis to strengthen the prosodic word boundary and facilitate word recognition. Another possibility is that infant-directed-speech might contain higher rates of glottal phonation for the purpose of easing parsing and lexical access. Therefore, future research should examine the extent to which adults increase their rates of /ʔ/-epenthesis when interacting with children.

My results also confirm recent experimental and corpus studies (Scobbie and Pouplier 2010; Pak 2016) showing that /ʔ/-epenthesis is not absent in adult phonology and that glottal phonation appears to be an alternative to ambisyllabic consonants in the repairs of word-external empty onsets. While the present study only tested young adults, further research should examine the production of glottal phonation in older adults. There is, after all, a possibility that young adults are more likely to repair empty onsets using glottal phonation than older adults since they are generally more likely to rely on creaky phonation as a sociolinguistic element indicating alignment with a particular social group (Davidson 2020, 11).

7.2. Prosodic Prominence

My categorical findings show that across groups, syllables with primary stress are more likely to be repaired by means of glottal phonation (79.03%) than syllables without primary stress (37.76%). As in the case of hiatus resolution (Davidson and Erker 2014), glottal phonation is mediated by prosodic prominence (Garellek 2013, 2014; Dilley, Shattuck-Hufnagel, and Ostendorf 1996; Redi and Shattuck-Hufnagel 2001). In addition, this study demonstrates that children above the age of 6 are sensitive to prosodic prominence when producing onsetless syllables. However, degree of glottalization (i.e., HNR<500) demonstrates a U-shaped behaviour with stress producing a more prominent effect in 9-10-year-olds than in either 6-to-8-year-olds or adults. That is, 9-to-10-year-olds maximize the phonation difference between syllables with primary stress and syllables without primary stress. This suggests a category formation behaviour: as 9-to-10-year-olds develop adultlike behaviour, they learn to restrict glottal phonation to strong positions and thus maximize the degree of glottal phonation in stressed syllables.

At this point, the results of the current study cannot tease apart the relative influence of stress and pitch accents as both suprasegmental features are conflated in this experiment. Future research should elicit content words in unaccented positions to better understand the relative importance of stress and pitch accents in glottal phonation.

7.3. Preceding Consonants

With respect to the effect of consonants, /l/ (M = 64.77%) and /s/ (M = 61.79%) demonstrate higher glottalization rates than /n/ (M = 48.62%). I believe that these values might be related to lexical frequency, and in particular, to the frequency of function word + content word co-occurrence. For this reason, I conducted a post-hoc corpus search using ChildFreq (Bååth 2010) and summed the number of occurrences per 100,000 words of the 24 possible combinations (e.g., *an onion, this onion, all onions*) in children between 12 and 71 months. I then collapsed occurrences per function word. My results showed that *an* + content word (19 occurrences) is more frequent than *this* + content word (12 occurrences), and that the difference is greater between the previous function words and *all* + content word (0 occurrences). Thus, I tentatively posit that frequency of co-occurrence might explain respective differences in the rates of /ʔ/-epenthesis between /l/ and /n/ and between /s/ and /n/. Consistent with this hypothesis, results from another study (Repiso-Puigdelliura 2021) show that children are more likely to glottalize with novel words than with high-frequency existing words.

My results for continuous measurements demonstrated that vowels in the condition of coda /s/ (M = 20.89 dB) were produced with higher degree of glottal phonation than vowels in the condition of coda /n/ (M = 23.00 dB) and coda /l/ (M = 23.42 dB). Nevertheless, acoustic measures did not show a significant difference between /n/ and /l/. One possible explanation is that the difference between modal phonation and glottal phonation in /n/ and /l/ was not large enough to result in significant differences at the acoustic level. For /s/, I believe that frication might have affected the vowels produced with modal phonation, as these present lower HNR<500 values (M = 22.12 dB, SD = 13.60 dB) than vowels produced with modal phonation in the condition /n/ (M = 27.87 dB , SD = 12.34 dB) and the condition /l/ (M = 32.84 dB , SD = 12.94 dB). Future research should elicit a comparable number of word-internal vowels (i.e., produced with modal phonation) in the three coda conditions to establish a baseline for modal phonation.

8. Conclusions

The findings of this study show that repair strategies of word-external onsetless syllables (i.e., /C#V/ sequences) continue to develop during late childhood until they are finally produced in an adultlike manner around the age of 9. Between the ages of 6 and 8 children epenthesize a glottal stop between the coda consonant and the following vowel (e.g., an[ʔ]onion). To a lesser degree, /ʔ/-epenthesis continues to be an option to repair word-external empty onsets during adulthood. My results also show that syllables with primary stress are more likely to be glottalized than syllables without primary stress in children and adults. Finally, the categorical data shows that coda /n/ is more likely to show /ʔ/-epenthesis than /l/ and /s/. I account for this asymmetry with frequency of function word + content word co-occurrence.

References

Athanasopoulou, Angeliki. 2018. “The Acquisition of Stress-Clash Resolution Strategies in Greek.” In *Proceedings of the 42nd Annual Boston University Conference on Language Development*, edited by Anne B Bertolini and Maxwell J Kaplan, 45–57. Somerville, MA: Cascadilla Press.

Bååth, Rasmus. 2010. “ChildFreq: An Online Tool to Explore Word Frequencies in Child Language.” *Lucs Minor*, no. 16.

Baayen, R H, D J Davidson, and D M Bates. 2008. “Mixed-Effects Modeling with Crossed Random Effects for Subjects and Items.” *Journal of Memory and Language* 59 (4): 390–412. https://doi.org/10.1016/j.jml.2007.12.005.

Bates, Douglas, Martin Mächler, Benjamin M. Bolker, and Steven C. Walker. 2015. “Fitting Linear Mixed-Effects Models Using Lme4.” *Journal of Statistical Software* 67 (1). https://doi.org/10.18637/jss.v067.i01.

Chevrot, Jean Pierre, Céline Dugua, Mylène Harnois-Delpiano, Anne Siccardi, and Elsa Spinelli. 2013. “Liaison Acquisition: Debates, Critical Issues, Future Research.” *Language Sciences* 39: 83–94. https://doi.org/10.1016/j.langsci.2013.02.011.

Chevrot, Jean Pierre, Aurélie Nardy, and Stéphanie Barbu. 2011. “Developmental Dynamics of SES-Related Differences in Children’s Production of Obligatory and Variable Phonological Alternations.” *Language Sciences* 33 (1): 180–91. https://doi.org/10.1016/j.langsci.2010.08.007.

Cohen, Wendy, and Carolyn Anderson. 2011. “Identification of Phonological Processes in Preschool Children s Single-Word Productions.” *International Journal of Language & Communication Disorders* 46 (4): 481–88. https://doi.org/10.1111/j.1460-6984.2011.00011.x.

Cruttenden, Alan. 1994. *Gimson’s Pronunciation of English*. New York: Arnold.

D’Introno, Francesco, Judith Ortiz, and Juan Sosa. 1989. “On Resyllabification in Spanish.” In *Studies in Romance Linguistics: Selected Papers from the Seventeenth Linguistic Symposium on Romance Languages*, 97–114. John Benjamins Publishing.

Davidson, Lisa. 2020. “The Versatility of Creaky Phonation: Segmental, Prosodic, and Sociolinguistic Uses in the World’s Languages.” *Wiley Interdisciplinary Reviews: Cognitive Science*, no. September: 1–18. https://doi.org/10.1002/wcs.1547.

Davidson, Lisa, and Daniel Erker. 2014. “Hiatus Resolution in American English: The Case against Glide Insertion.” *Language* 90 (2): 482–514. https://doi.org/10.1353/lan.2014.0028.

Dilley, Laura C, Stefanie Shattuck-Hufnagel, and M. Ostendorf. 1996. “Glottalization of Word-Initial Vowels as a Function of Prosodic Structure.” *Journal of Phonetics* 24 (4): 423–44. https://doi.org/10.1006/jpho.1996.0023.

Dodd, Barbara, Alison Holm, Zhu Hua, and Sharon Crosbie. 2003. “Phonological Development: A Normative Study of British English-Speaking Children.” *Clinical Linguistics and Phonetics* 17 (8): 617–43. https://doi.org/10.1080/0269920031000111348.

Dugua, Céline. 2006. “Liaison , Segmentation Lexicale et Schémas Syntaxiques Entre 2 et 6 Ans Un Modèle Développemental Basé Sur l ’ Usage.” *Language* 50 (2): 333–50.

Esling, John H., Katherine E. Fraser, and Jimmy G. Harris. 2005. “Glottal Stop, Glottalized Resonants, and Pharyngeals: A Reinterpretation with Evidence from a Laryngoscopic Study of Nuuchahnulth (Nootka).” *Journal of Phonetics* 33 (4): 383–410. https://doi.org/10.1016/j.wocn.2005.01.003.

Freitas, M João. 2003. “The Acquisition of Onset Clusters in European Portuguese.” *Probus*. Vol. 15.

Garellek, Marc. 2013. “Production and Perception of Glottal Stops.” University of California Los Angeles.

———. 2014. “Voice uality Strengthening and Glottalization.” *Journal of Phonetics* 45 (1): 106–13. https://doi.org/10.1016/j.wocn.2014.04.001.

Ito, Junko, and Armin Mester. 2009. “The Onset of the Prosodic Word.” *Phonological Argumentation: Essays on Evidence and Motivation* 227: 260. https://www.researchgate.net/publication/247934087.

Kahn, Daniel. 1976. “Syllable-Based Generalizations in English Phonology.” Massachusetts Institute of Technology. https://doi.org/10.4324/9781315688121.

Keating, Patricia, Marc Garellek, and Jody Kreiman. 2015. “Acoustic Properties of Different Kinds of Creaky Voice.” In *ICPhS 2015–The 18th International Congress of Phonetic Sciences*. Glasgow. https://www.researchgate.net/publication/281119746.

Kehoe, Margaret, Geraldine Hilaire-Debove, Katherine Demuth, and Conxita Lleó. 2008. “The Structure of Branching Onsets and Rising Diphthongs: Evidence from the Acquisition of French and Spanish.” *Language Acquisition* 15 (1): 5–57. https://doi.org/10.1080/10489220701774229.

Krom, G. De. 1993. “A Cepstrum-Based Technique for Determining a Harmonics-to-Noise Ratio in Speech Signals.” *Journal of Speech and Hearing Research*. https://doi.org/10.1044/jshr.3602.254.

Levelt, Clara C., Niels O. Schiller, and Willem J. Levelt. 2000. “The Acquisition of Syllable Types.” *Language Acquisition* 8 (3): 237–64. https://doi.org/10.1207/s15327817la0803_2.

MacWhinney, Brian. 2000. “The CHILDES Project: Tools for Analyzing Talk.” Edited by Lawrence Erlbaum Associates. *Child Language Teaching and Therapy*. Mahwah, NJ. https://doi.org/10.1177/026565909200800211.

Newton, Caroline, and Bill Wells. 1999. “The Development of Between-Word Processes in the Connected Speech of Children Aged between Three and Seven.” In *Pathologies of Speech and Language. Advances in Clinical Phonetics and Linguistics.*, edited by Maassen & P. Groenen. Whurr.

———. 2002. “Between-Word Junctures in Early Multi-Word Speech.” *Journal of Child Language* 29 (2): 275–99. https://doi.org/10.1017/S0305000902005044.

Nittrouer, Susan. 1993. “The Emergence of Mature Gestural Patterns Is Not Uniform: Evidence from an Acoustic Study.” *Journal of Speech and Hearing Research* 36 (5): 959–72. https://doi.org/10.1044/jshr.3605.959.

Pak, Marjorie. 2016. “How Allomorphic Is English Article Allomorphy?” *Asudeh & Klein*. https://doi.org/10.5334/gjgl.62.

Prince, Alan, and Paul Smolensky. 1993. “Optimality Theory: Constraint Interaction in Generative Grammar.”

———. 2004. *Optimality Theory: Constraint Interaction in Generative Grammar.* Blackwell Publishers.

Redi, Laura, and Stefanie Shattuck-Hufnagel. 2001. “Variation in the Realization of Glottalization in Normal Speakers.” *Journal of Phonetics* 29 (4): 407–29. https://doi.org/10.1006/jpho.2001.0145.

Repiso-Puigdelliura, Gemma. 2021. “Lexically-Conditioned Child Acquisition of English Empty Onset Repairs.” In *LSA 2021 Virtual Annual Meeting*. Online.

Roberts, Joanne E., Margaret Burchinal, and Marianna M. Footo. 1990. “Phonological Process Decline from 2 1 2 to 8 Years.” *Journal of Communication Disorders* 23 (3): 205–17. https://doi.org/10.1016/0021-9924(90)90023-R.

Rubach, Jerzy. 1996. “Shortening and Ambisyllabicity in English.” *Phonology* 13 (2): 197–237. https://doi.org/10.1017/S0952675700002104.

Scobbie, James M., and Marianne Pouplier. 2010. "The Role of Syllable Structure in External Sandhi: An EPG Study of Vocalisation and Retraction in Word-Final English /L/." *Journal of Phonetics* 38 (2): 240–59. https://doi.org/10.1016/j.wocn.2009.10.005.

Selkirk, E. 1982. "The Syllable." In *The Structure of Phonological Representations*, edited by Harry van der Hulst and Norval Smith, 2:337-383. Dordrecht: Foris Publications.

Singh, Latika, and Nandini C Singh. 2008. "The Development of Articulatory Signatures in Children." *Developmental Science* 11 (4): 467–73.

Stemberger, Joseph Paul. 1993. "Glottal Transparency." *Phonology* 10 (1): 107–38. https://doi.org/10.1017/S0952675700001755.

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