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Linguistically Informed Acoustic and Perceptual Analysis of Bilingual Children's Speech Productions: An Exploratory Study in the Jamaican Context

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ABSTRACT

Purpose: The aim of this study was to characterize speech acoustics in bilingual preschoolers who speak Jamaican Creole (JC) and English. We compared a standard approach with a culturally responsive approach for characterizing speech sound productions. Preschoolers' speech productions were compared to adult models from the same linguistic community as a means for providing confirmatory evidence of typical speech patterns specific to JC–English speakers.
Method: Two protocols were applied to the data collected using the Diagnostic Evaluation of Articulation and Phonology (DEAP) Articulation subtest: (a) the standardized DEAP protocol and (b) a culturally and linguistically adapted protocol reflective of the Jamaican post-Creole (English to Creole) continuum. The protocols were used to analyze responses from JC-English–speaking preschoolers (n = 119) and adults (n = 15). Responses were analyzed using acoustic (voice onset time, whole-word duration, and vowel duration) and perceptual (percentage of consonant correct–revised and response frequencies) measures.
Results: The culturally responsive protocol captured variation in the frequency and acoustic differences produced in the post-Creole continuum, with higher amounts of "other" responses compared to "standard" target responses for both children and adults. Adults' whole-word durations were shorter and showed more consistent prevoicing during initial plosives compared to the children.
Conclusions: Applying culturally responsive methods, including knowledge of the variation produced in the post-Creole continuum and with adult models from the same linguistic community, improved the ecological validity of speech characterizations for JC–English preschoolers. Acoustic properties of speech should be investigated further as a means of describing bilingual development and distinguishing between difference and disorder.
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Bilingual populations present with complex communication characteristics and needs that must be considered for the appropriate diagnosis of communication disorders. Although a cultural and linguistic mismatch exists between the multilingualism of the clientele and the monolingualism of the field of speech-language pathology (American Speech-Language-Hearing Association [ASHA], 2021), clinicians must use culturally appropriate practices to better understand their client's abilities, especially in diagnostic evaluations (ASHA, n.d.). Significant strides have been made toward investigating and developing evidence-based methods for evaluating bilingual speech skills (Fabiano-Smith et al., 2021; Peña & Bedore, 2011); however, bilingual children continue to be at a greater risk for misdiagnosis than their monolingual counterparts. Despite the prevalence of speech

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disorders being similar for monolingual and bilingual populations, bilingual children are under- and overreferred for speech services (Hambly et al., 2013; McLeod et al., 2017; Stow & Dodd, 2005; Winter, 2001). This increased risk suggests improved identification and assessment of speech disorders in bilingual children are needed.

Various factors contribute to the increased risk of misdiagnosis in bilingual populations, including cross-linguistic interactions in bilingual speech, unreliable and culturally insensitive assessment practices, and a paucity of normative data for a vast range of bilingual profiles (Edwards & Munson, 2012; Fabiano-Smith, 2019; Guiberson & Atkins, 2012; Hambly et al., 2013; Stow & Dodd, 2005; Verdon et al., 2015). The increased risk for misdiagnosis of speech disorders results from both under- and overdiagnosis. Naturally occurring bilingual speech patterns that arise from the interaction or interdependence between languages (Paradis et al., 2021) can resemble speech sound disorder (SSD) characteristics (Fabiano-Smith & Barlow, 2010; McLeod & Goldstein, 2012). This leads to the possibility of overreferral and overdiagnosis for bilingual children (McLeod et al., 2017). However, bilingual children are also at risk of misdiagnosis from underreferral and underdiagnosis when atypical speech patterns are mistaken for typical cross-linguistic speech patterns (Hambly et al., 2013; McLeod et al., 2017; Stow & Dodd, 2005). There is no easy solution for avoiding misdiagnosis of SSDs in bilingual children as every language pairing will result in different presentations of speech characteristics. A thorough understanding of diverse bilingual cross-linguistic features is needed to support accurate diagnosis and to make appropriate decisions concerning intervention (Barragan et al., 2018; Guiberson & Ferris, 2019).

In making the appropriate determination about the need for speech and language services, there has been an overreliance on formal standardized testing that makes use of normative data (Fabiano-Smith, 2019; Scarpino & Goldstein, 2012; Skahan et al., 2007). However, research has consistently shown that bilingual children are disadvantaged when assessed with these types of tests and consistently underperform when evaluated using these tools (Barragan et al., 2018; Bedore et al., 2005; De Lamo White & Jin, 2011). Such underperformance indicates a lack of sensitivity from the assessment tools and/or the administration of the tools to adequately capture bilingual children's communication skills (Wright Karem & Washington, 2021). To date, efforts have been made to investigate and establish normative data for frequently occurring language pairings (e.g., Spanish–English; Fabiano-Smith & Barlow, 2010; Goldstein & Bunta, 2012; Peña et al., 2014) in locations such as the United States where large numbers of speakers of these pairings are evident.

Knowledge of phonological development and speech characteristics for languages and language pairings that have previously received little or no attention in the research is needed to provide clinicians with best practice guidelines on the assessment and intervention for SSDs (e.g., Haitian Creole, Archer et al., 2018; Guyanese Creole, Telford Rose et al., 2020; Jamaican Creole [JC], Washington et al., 2017). Since disorders must be evident in both languages, it is recommended that bilingual children be assessed in a bilingual context (i.e., considering all languages they are exposed to; ASHA, n.d.; McLeod et al., 2017). Despite this recommendation, speech evaluations continue to be administered mostly in a monolingual context in English in the United States (Bonifacci et al., 2020; Caesar & Kohler, 2007; McLeod et al., 2017; Skahan et al., 2007). These practices remain for a variety of reasons, including the paucity of appropriate assessment tools in different languages, the homogeneity of the speech-language pathology field (i.e., mainly speakers of the mainstream language and/or monolinguals), and the need for increased specialized training in understanding the differences related to culturally and linguistically diverse children (Guiberson & Atkins, 2012; Verdon et al., 2015). The purpose of this study was to investigate and determine the appropriateness of two different approaches for characterizing speech patterns in an understudied bilingual population: a standard and a culturally adapted approach. This study also applied and described the application of objective speech acoustic measures for characterizing bilingual speech. Although this study focused on methods for informing the speech characteristics of a typical developing population, some reference is made to suggest how, by extension, the methods in this work could improve accurate diagnoses of speech disorders in this bilingual population.

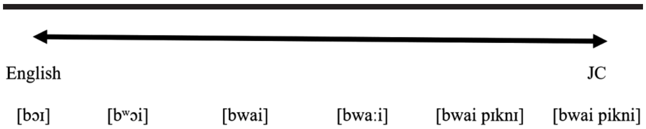
Bilingual JC–English Speakers

The number of bilingual children on speech-language pathologists' (SLPs) caseloads is increasing and is projected to continue to increase (Wright Karem et al., 2019). Therefore, a pressing need exists for culturally responsive solutions and methods to avoid the resulting increased risk of misdiagnoses. Large populations of JC–English speakers can be found in the United States (U.S. Census Bureau, 2017), Canada (Hinrichs, 2011), and the United Kingdom (Mair, 2003). JC–English speakers offer unique bilingual profiles (León et al., 2021; Washington, 2012; Washington et al., 2017), but their speech production remains understudied (Abu El Adas et al., 2020). Research involving JC–English speakers can serve as a theoretical model to inform research and practice with other similar types of bilingual populations that share linguistic paradigms, such as other Creole languages and their lexifiers, other languages with extensive cognates (e.g., Catalan and Spanish), and divergent dialects of a language (e.g., African American English and General American English).

Most JC–English speakers are considered simultaneous bilinguals (Alleyne, 1976; León et al., 2021; Washington et al., 2019) due to exposure to both languages from birth (Paradis et al., 2021). JC is primarily an oral language, with the standardization of its written form occurring in 2002 (Cassidy, 1966; Jamaican Language Unit, 2009; Washington, 2012). JC is an independent language, with English serving as a heritage and a lexifier language to JC. The languages also share a linguistic foundation and similar vocabulary (Devonish & Harry, 2008). JC–English speakers have a continuum of language use to select from when they speak, also known as the post-Creole continuum (Meade, 2001; Patrick, 2004; Wassink, 1999). This linguistic continuum ranges from English to JC, with each end of the continuum containing distinct language-specific phonological, lexical, and grammatical differences (Patrick, 2004; Wassink, 1999). In between those polar "ends," there are numerous response varieties that reflect shared features from both languages, including phonological features and cognates (Abu El Adas et al., 2020; Devonish & Harry, 2008; Patrick, 2004; Washington et al., 2017). Figure 1 illustrates this post-Creole continuum for the word "boy."

Previous research (Washington et al., 2017) has applied knowledge of the post-Creole continuum to develop a culturally and linguistically adapted protocol of the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd et al., 2006), including the Articulation subtest. The DEAP Articulation subtest can be used to assess articulation skills at the single-word level for children 3;0 to 8;11 (years;months). The adapted DEAP protocol assesses the same stimulus words as the DEAP but contains an increased number of appropriate English-to-JC responses. For example, for the stimulus word "fish," appropriate responses include [fɪʃ, fiʃ, fɪʧ] whereas the standard DEAP only allows [fɪʃ] as an appropriate response. The development of culturally responsive protocols, reflective of the language community (or linguistic profiles), serves to reduce the likelihood of misdiagnosis while also informing the speech production profile of children who use more than one language on a daily basis (McLeod et al., 2013, 2017) yet remains underresearched. In response to this need, this study aimed to contribute to this growing area of research by incorporating additional varieties of language-specific linguistic responses that were deemed culturally acceptable in the assessment of bilingual speakers. We specifically applied acoustic and perceptual methods to inform speech characteristics in the JC–English context.

Figure 1. An example of the post-Creole continuum (i.e., English to Jamaican Creole [JC]) for the target "boy." Example of varied productions of "boy" that ranges from standard English to JC. It is also an example of the cultural and linguistically adapted Diagnostic Evaluation of Articulation and Phonology (Dodd et al., 2006) Articulation subtest protocol for JC speakers.



Measures for Characterizing Speech Production

Acoustic analysis provides objective data that can be useful in advancing our understanding of speech characteristics (Ishikawa et al., 2017), developmental trajectory (Vorperian & Kent, 2007), and overall assessment of speech disorders (Levy et al., 2016). However, few studies with Jamaican participants have applied acoustic analyses. Of the available few, the majority examined various spectral (i.e., energy distribution) and temporal (i.e., timing) characteristic features of vowels in both children (Coy & Watson, 2020; Lacoste, 2012) and adults (Rosenfelder, 2009; Wassink, 1999, 2006). These works have described the variation and overlap of vowels found in the post-Creole continuum as influenced by Jamaican, British, and American English and concluded that more precise speech characterization was needed for this population. The current effort broadens the existing work on Jamaican speech by describing select acoustic factors that can serve to describe typical speech duration patterns and improve our understanding of acoustic profiles in these children. It also extends the analysis of consonants and vowels, which impacts speech intelligibility, to better inform Jamaican children's typical speech development (Kent & Rountrey, 2020). These analyses improve our understanding of typical development for this population and can help progress clinical accuracy in differentiating communication differences (i.e., rule-governed and typical within culture) from speech disorder in the future.

Voice onset time (VOT; Lisker & Abramson, 1964) plays a large role in the perceptual differentiation of phonemic categories (Lisker & Abramson, 1967), and it has been shown to be affected by different factors including age, gender, languages spoken by the speaker, and the word's phonotactic structure (Swartz, 1992). VOT is the time from vocal fold vibration associated with the plosive release to the initiation of voicing and is measured as positive VOT (Lisker & Abramson, 1967; Stoehr et al., 2018). When voicing occurs prior to the plosive, it is measured as negative VOT and can also be referred to as "prevoicing." The VOT duration is imperative for listeners to distinguish voiced and voiceless plosives, and the distinction (as determined by VOT values) can differ by language and/or cross-linguistic influence (Lisker & Abramson, 1964; Stoehr et al., 2018). The presence of prevoicing has been frequently found to be inconsistent for school-age or younger monolingual and bilingual children but more adultlike in adolescence, meaning that this could likely be attributed to developmental motor control and timing (Stoehr et al., 2018). Several studies investigating bilingual speech characteristics disagree on the cause for inconsistent prevoicing and/or the absence of prevoicing (Stoehr et al., 2018).

Bilingual VOT values have been shown to resemble monolingual speech characteristics in the majority language on some occasions (McCarthy et al., 2014). Others have found that bilingual VOT values varied from monolingual speakers by showing a distinct VOT range that overlaps the languages spoken (Fabiano-Smith & Bunta, 2012; Kehoe et al., 2004; Stoehr et al., 2018). Differences in bilingual voicing contrast have been attributed to cross-linguistic transfer or contextual factors (e.g., language exposure and bilingual environment). For example, as reported by Fabiano-Smith and Bunta (2012), their monolingual and bilingual participants' VOT values differed mainly in English (bilinguals produced shorter values) but not in Spanish.

Additionally, percentage of consonants correct (PCC; Shriberg & Kwiatkowski, 1982) is a metric commonly used for evaluating and characterizing speech that considers distortions, deletions, and substitution responses as errors. The calculation indicates the percentage of consonants produced accurately from an intended target response, perceptually determined by an expert listener. PCC–revised (PCC-R; Shriberg et al., 1997) is calculated similarly but does not count distortions as errors. Previous work by Fabiano-Smith and Hoffman (2018) found that PCC-R predicted phonological ability in monolinguals and bilinguals over 5;0 and so has been suggested as a suitable metric for linguistically diverse children. Its frequent use, including with bilingual populations (Fabiano-Smith & Goldstein, 2010; Fabiano-Smith & Hoffman, 2018) and clinical facility, provides both research and clinical relevance.

Purpose

The overarching objective of this work was to improve the understanding of speech sound production in JC-English–speaking bilingual children and to serve as a foundation for future works in guiding better assessment and identification of speech disorders for this population. In this effort, we investigated speech acoustics and perceptual speech assessment in typically developing bilingual preschoolers using single-word productions by adult models from the same linguistic background as a comparison. We developed a new method for examining speech in a bilingual context by way of a culturally responsive protocol informed by adult speakers of the same linguistic community. To achieve our objective, we applied two methodologies for capturing speech sound productions at the single-word level using the DEAP Articulation subtest: (a) the standardized DEAP protocol and (b) a culturally responsive (i.e., adapted) protocol specific to bilingual JC–English speakers (Washington et al., 2017). Speech samples were obtained in the English context (i.e., assessments conducted in English), where bilingual children have a higher risk for misdiagnosis.

The first aim applied objective acoustic analysis of durational measures (e.g., VOT, Lisker & Abramson, 1964; whole-word duration, Macrae et al., 2010; and vowel duration, Redford & Gildersleeve-Neumann, 2009) in JC-English–speaking preschoolers, thereby sharpening the identification of typical differences from adult productions. Adults from the same linguistic community were included to provide relational analyses for the speech patterns examined. These analyses compare the children's skills to an appropriate adult target (Stoel-Gammon, 1985) and have been reported to be appropriate for assessing bilingual children (Goldstein & Fabiano, 2007; McLeod et al., 2017; Scarpino & Goldstein, 2012). This approach has been successfully applied to language samples for JC-English–speaking children to better inform language skills (Wright Karem & Washington, 2021). It was hypothesized that statistically significant differences existed between children and adults when assessed with the standardized DEAP protocol in the monolingual (i.e., standard) context. Additionally, figures are used to illustrate the preschoolers' productions and include descriptive acoustic measures of all linguistic response variations.

The second aim described a standard DEAP approach and an adapted protocol for bilingual speakers that considered the post-Creole continuum. The adapted protocol was developed using a culturally responsive and bilingual approach containing linguistic and phonotactic modifications. Word frequencies were reported for children compared to adults. A comparison of PCC-R was also undertaken between children and adults across the two methodologies. It was hypothesized that there would be smaller margins of difference between adult and child productions when using the linguistically informed protocol than when using the standardized protocol. The two research aims addressed were as follows:

Aim 1: To investigate speech acoustics as a means to describe differences between children and adults in the Jamaican context.

Aim 2: To describe differences in PCC-R and word frequencies in a standard and a culturally and linguistically adapted protocol in bilingual speakers using preschoolers and adult models.

Method

Study Approval

Ethical approval for the Jamaican Creole Language Project was obtained from the Institutional Review Board of the University of Cincinnati and the Medical Ethics Board of the Faculty of Medicine, University of the West Indies Mona Campus, Kingston, Jamaica. Support and permission to engage in research was also obtained from the participating early learning centers and boards in Jamaica where data were collected. Licensure for the practice of speech therapy in Jamaica was obtained from the Council for Professions Supplementary to Medicine. Consent was obtained from adult participants, whereas parental consent, with child assent, was gathered for child participants.

Study Context

Participant data were collected from a larger study, the Jamaican Creole Language Project, in which usable audio recordings for the purpose of acoustic analysis were available for 119 children and 15 adults, resulting in the following number of recordings for each parameter: 1,024 for VOT, 1,891 for whole-word duration, and 1,892 for vowel duration. A description of the Jamaican Creole Language Project is provided in Washington et al. (2017, 2019) and León et al. (2021). These recordings form the basis of the data reported in this article. Only data and procedures relevant to this study will be described here.

Participants

Children

Data from 119 typically developing, simultaneous bilingual children who used JC and English were analyzed in this study. Children were recruited from four different schools in Kingston, Jamaica. The age range of participants was 3;4–5;11 (M = 4;10, SD = 6.7), and the sample consisted of 66 girls (55.5%) and 53 boys (44.5%). As the objective of this study was to describe typical speech patterns in bilingual typically developing children, all participants met the following inclusion criteria: (a) used JC and English at home and at preschool, as reported in parents and teacher questionnaires; (b) passed binaural hearing screening at 25 dB HL for 1, 2, and 4 kHz; (c) had no neurological deficits or pervasive developmental disorders based on parent report; (d) achieved the age-based criterion on the Oral Motor subtest of the DEAP (Dodd et al., 2006); (e) achieved a standard score of ≥ 72 on the Primary Test of Nonverbal Intelligence (PTONI; Ehrler & McGhee, 2008); and (f) achieved a mean score of ≥ 4.12 on the English Intelligibility in Context Scale (ICS; McLeod et al., 2012a) and the ICS-JC (McLeod et al., 2012b; Washington et al., 2017). A cutoff of 72 was used for the PTONI reflecting the criteria for the larger data set of JC–English bilinguals that data for this study was drawn from (León et al., 2021). The cutoff of 72 is less strict and was applied to account for variability in child performance, administrator performance, and cultural differences to mitigate misidentification. Bilingual children frequently score lower than monolingual children on norm-referenced assessments from typical variation in performance not being captured accurately (Barragan et al., 2018). A lower cutoff score reduces the possibility of excluding children that should qualify while having other culturally appropriate tools (i.e., parent questionnaires) to cross-validate the children's inclusion in this study. A cutoff of 4.12 was chosen for the ICS, a parent questionnaire reporting on functional intelligibility, because it was successful in discriminating typically developing from suspected SSD in both JC (León et al., 2021) and English (León et al., 2021) in Jamaican preschoolers. Although our study focused on the optimal approach for assessing speech in an English context, both languages were considered when evaluating these bilingual children for reliable identification of speech function in keeping with standards of practice recommendations (e.g., McLeod et al., 2017).

Adults

Audio recordings of 15 JC-English–speaking adults aged 19;0–51;7 (M = 38;9, SD = 10.7) were included in this study, with the majority being women (n = 12, 80.0%). All adult participants were recruited in Kingston, Jamaica, and belonged to the same linguistic community as the child participants. Adult participants self-reported no history of speech, language, or hearing difficulties and language proficiency in both JC and English. Where a participant's self-report of language proficiency could not be obtained, this was provided by the participant's employer. None of the adult participants were parents of children involved in this study.

Materials

Speech Stimulus

Single-word responses to the DEAP (Dodd et al., 2006) were elicited from all participants. The DEAP is a norm-referenced assessment battery of speech ability and is used to determine children's articulation, phonological, and oral motor skills through various subtests and screeners. All participants completed the DEAP Articulation subtest, which elicits word-level speech for 30 words and provides a consistent measure of consonants and vowels. Although Jamaican preschoolers are outside the established normed sample, the DEAP has been used previously in a validation study with this population using an adapted scoring protocol (Washington et al., 2017). The adapted protocol of the DEAP was developed based on adult speech sound productions in JC and English to reflect the post-Creole continuum, integrating culturally appropriate responses such as lexical and phonological variations. It also accounts for the Jamaican phonological system, which consists of 22 consonants and 12 vowels (Jamaican Language Unit, 2009), differing in quantity from the English phonological system, which contains 24 consonants and 20 vowels (Dib, 2019).

A subset of words from the DEAP Articulation subtest was selected for analysis (see Table 1). Words were chosen based on the following characteristics: (a) being monosyllabic, (b) containing singleton consonants in initial word position, and (c) containing consonant–vowel–consonant (CVC) phonotactic structures. These characteristics were critical for capturing the effect of phonotactic structure on durational measures (Aldrich & Simonet, 2019), maintaining a similar CVC initial structure, and analyzing the impact of consonant and vowel sequences. It should be noted that words containing rhotic elements were excluded due to the influence of these elements on duration being beyond the scope of this study. Twenty-three of the 30 words met these criteria and were included as stimuli in this research. Seven words were excluded for the following reasons: being multisyllabic (yellow, zebra, and orange), containing an initial consonant cluster (snake and crab), or containing a rhotic consonant or vowel (chair and ring).

Various response options (i.e., lexical and phonological variations) extending from the subset of selected words were included to allow for greater representation of culturally appropriate productions (post-Creole continuum variation) for this population. To maintain methodological rigor, the response production criteria for this study included any of the following phonotactic parameters to the CVC target word: CVC, CVCV, and CVCC. As an example, acceptable responses for the stimulus word "pig" were [pɪg, pɪgə, pɪgi, pɪgɪ, pɪgz, pɔk, hag, hagə, pigi, pig]; however, [ag, swaɪn, sɔʊ, saʊ, ʧɪɛntɔn], though acceptable in the Jamaican context, were excluded from analysis, adhering to the aforementioned restrictions.

Table 1. Acoustic duration measurements for word subset.

Acoustic durational measurements	Word subset
VOT	Bird, door, car, girl, boy, television
Whole word/vowel	Moon, knife, fish, van, thumb, this, sock, sheep, jam, legs, watch, house, five, foot
VOT and whole word/vowel	Pig, teeth, ball

Note. Subsets of words were selected from the Diagnostic Evaluation of Articulation and Phonology (Dodd et al., 2006) Articulation subtest. VOT = voice onset time.

Procedure

Data Collection

The speech samples were recorded using a Zoom H4N or H6N portable recorder with a Movo LV4-C XLR unidirectional cardioid lavalier microphone attached to a fitted vest worn by the speaker. Samples were digitized with a sampling rate of 22 kHz and 24-bit encoding. Audio recordings for all participants were completed in a quiet room in the school environment.

As previously mentioned, participants took part in the larger Jamaican Creole Language Project, which consisted of the administration of the DEAP twice, counterbalanced by language. For this study, the children's speech samples consisted of single-word responses to the DEAP Articulation subtest in English administered by monolingual English-speaking SLPs. Although randomized presentation of stimuli is typically preferred to offset concerns related to order of presentation, the test was administered following the standardized procedure in the test manual, reflecting clinical best practice. If responses during the picture-elicited task were incorrect or the children did not respond, the SLP verbally provided a phonetic or semantic cue, then a binary forced choice with the target word being modeled first. If the children continued to produce an incorrect response, the SLP modeled the target word to be repeated. Most responses were spontaneously produced (> 95%).

The adults' speech samples consisted of 148 possible variations from the DEAP adapted protocol; that is, all variations of the 23 words (Washington et al., 2017). For example, for the stimulus word "fish," adults were asked to produce the different possible responses: [fɪʃ, fiʃ, fɪʧ]. JC-English–speaking SLPs administered the DEAP and modeled each variation of the word; however, not all adults repeated every variation, particularly the standard options (five words were not produced in the standard manner despite a model being provided). For example, many adults produced [pɪgə] despite the SLP model of [pɪg] being repeatedly provided. The speech samples provided by each adult encompassed the post-Creole continuum. The observed adult speech patterns thus support the presence of patterns produced by JC-English–speaking children. One production was measured per child and adult; if a participant repeatedly produced a target word, it was not due to an elicited request.

Data Analysis

Acoustic Duration Analysis

All audio recordings were transcribed using broad transcription and acoustically measured using the Praat speech analysis software (Version 6.1.40; Boersma & Weenink, 2018). The subset of 23 words was analyzed using three parameters to determine durational measurement: VOT (Lisker & Abramson, 1964), whole-word duration (Macrae et al., 2010), and vowel duration (Redford & Gildersleeve-Neumann, 2009). These durational measurements are all critical for the perception of speech and intelligibility and are also informative for possible cross-linguistic characteristics and motor abilities of bilingual children. A detailed protocol described operational guidelines to identify onset and offset markers in different phonetic contexts for the acoustic measures (see the Appendix). Members of the research team used visual and auditory information from the acoustic waveform and the wideband spectrogram to make onset/offset decisions. Utterances were excluded if the waveform and/or spectrogram was interrupted (e.g., background noise) prior to including as data in the study, resulting in the exclusion of 1,559 recordings (24.29%). Table 1 illustrates the durational analysis for each word.

Nine initial stop consonant words that included cognate pairs (e.g., voice and voiceless pairs /p/, /b/) were used to measure VOT. VOT was measured as the duration of time from the burst of the plosive to the first onset cycle of the following vowel, defined as the first cycle detected through Praat's pitch period capabilities. Measures taken from the burst to the onset of voicing were measured as positive integers (Lisker & Abramson, 1964). Prevoicing, defined as the presence of voicing prior to the plosive burst, was measured from initial voicing to the burst and recorded as a negative VOT value (Adi et al., 2016). Based on the words from the DEAP Articulation subtest and the word criteria, the participants had relatively balanced opportunities for different places of articulation, which included the following potential opportunities: four bilabial, three alveolar, and two velar words. All standard and nonstandard VOT responses were recorded and included if the initial CV phonotactic structure was produced. Line graphs that illustrate the acoustic performance for standard English compared to nonstandard (post-Creole continuum) productions (e.g., VOT for standard and all nonstandard variations of "teeth") are presented (see Figures 2–4).

Seventeen stimulus words were used to measure whole-word and vowel duration to provide substantial information for the acoustic characterization of speech (Coy & Watson, 2020; Vorperian & Kent, 2007). Acoustic boundaries varied based on the phonotactic structure, given the difference of energy concentration that can be spectrally visible (see the Appendix). For example, for words beginning or ending with nasals, onsets and offsets were marked at the first or last pitch period of the low-frequency nasal murmur, respectively, whereas a sibilant onset/offset was determined from high-frequency energy of > 5 kHz (Macrae et al., 2010).

The research team engaged in transcription and acoustic extraction of the participants' speech samples, with all members being part of the Pediatric Language, Literacy & Speech Outcomes Lab at the University of Cincinnati, directed by the second author. All team members had successfully completed the lab's orientation training, which included training on JC linguistic features. All team members also completed training in the processes related to the durational measures analyzed in this study. A total of nine trained research assistants were available for the purpose of analyses, and each team member was assigned a subset of analyses (e.g., the first author completed 45.19%, and the rest of the analyses were assigned to the remaining six members: 8.15%, 8.89%, 18.52%, 9.63%, 2.22%, 2.96%, 3.70%, and 0.74%).

Reliability

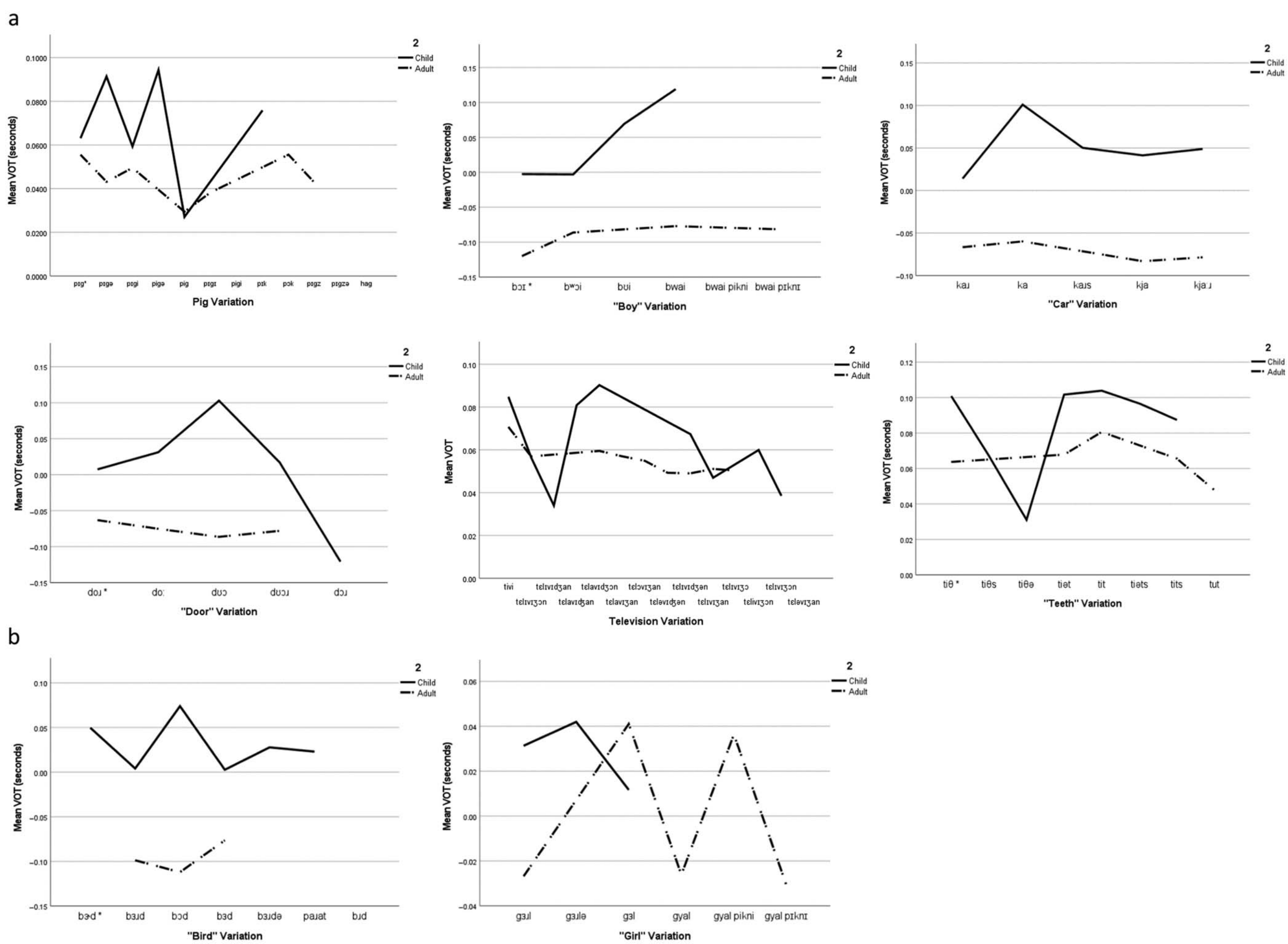
Interrater training reliability was established for all team members prior to beginning analyses. The data used for training reliability were similar in scope to that used for the task reliability in terms of the recording quality, the age range of the participants, and the calculations performed (VOT, whole word, and vowel duration). The intraclass correlation coefficient (ICC) for interrater reliability for the training was established using the *irr* R package (Gamer et al., 2019) and was found to be 90.0% and above (range: 90.2%–99.8%). Although there is not a standard consensus on acceptable ICC, the following rubric has been applied in the published literature based on the 95.0% confidence interval of the ICC estimate: values less than .5 are indicative of "poor" reliability; values between .5 and .75 are indicative of "moderate" reliability; values between .75 and .9 are indicative of "good" reliability; and, finally, values greater than .9 are indicative of "excellent" reliability (cf. Koo & Li, 2016). The training ICC scores above 90.0% can be interpreted as excellent reliability.

Interrater reliability was also completed for a sample of 10% (n = 13) of participants, ensuring that each age group was represented for the acoustic analyses (VOT, whole word, and vowel duration). Interrater reliability ratings were completed by the first author who was blinded to the others' data pull, therefore representing data not originally completed by the first author. Reliability ratings were achieved using IBM Statistical Package for the Social Sciences Version 27 (SPSS). The mean reliability across all measures was 93.4% (vowel duration mean: 95.5%, range: 93.9%–96.7%; VOT mean: 90.1%, range: 84.8%–93.5%; whole-word duration mean: 94.5%, range: 92.5%–95.9%) and was indicative of excellent reliability (Koo & Li, 2016).

Consonant Accuracy

PCC-R was established for children and adults through the consideration of two protocols: the original DEAP Articulation English protocol, referred to as

Figure 2. (a, b) Mean voice onset time duration measures between children and adults. Words with asterisks represent the standard/expected production. VOT= voice onset time.



"standard," and the culturally responsive DEAP Articulation protocol for JC speakers, referred to as "adapted," hereafter. The standard PCC-R value was calculated using the expected target word for the standard English DEAP, whereas the adapted PCC-R value was calculated using the target word from the adapted DEAP. Adult productions provided the data to evaluate PCC-R for standard English and adapted contexts. ICC scores for interrater reliability were established using SPSS for a sample of 10% (n = 13) of the data set. The average scores for the PCC-R were 95.4% (range: 82.4%–98.7%) using the standard protocol and 98.4% (range: 95.1%–99.5%) using the adapted protocol, indicative of "excellent" reliability (Koo & Li, 2016).

Statistical Analysis

IBM SPSS Version 27 was used to analyze all data. To categorize the children's speech sound productions, data were analyzed in two contexts: first, using the standard protocol, and second, using the adapted protocol. Of note is the number of stimulus words used to address each of the aims. For Aim 1, 18 of the 23 stimulus words were used to analyze standard target productions between adult and child participants. Fewer stimulus words were available for inclusion in Aim 1 because adults only produced 18 of the 23 stimulus words in the standard manner needed to complete the analyses. This observation was described earlier in the data collection procedures. However, for Aim 2, all 23 stimulus words were available for use in analyses that compared adult and child productions for the adapted protocol.

Different measures and analyses were used to address each of the aims. For Aim 1, the measure used was acoustic duration of single-word production for children and adults for the standard English production. To address this aim, four statistical approaches were used.

Figure 3. (a, b, c) Mean vowel duration measures between children and adults. Words with asterisks represent the standard/expected production.

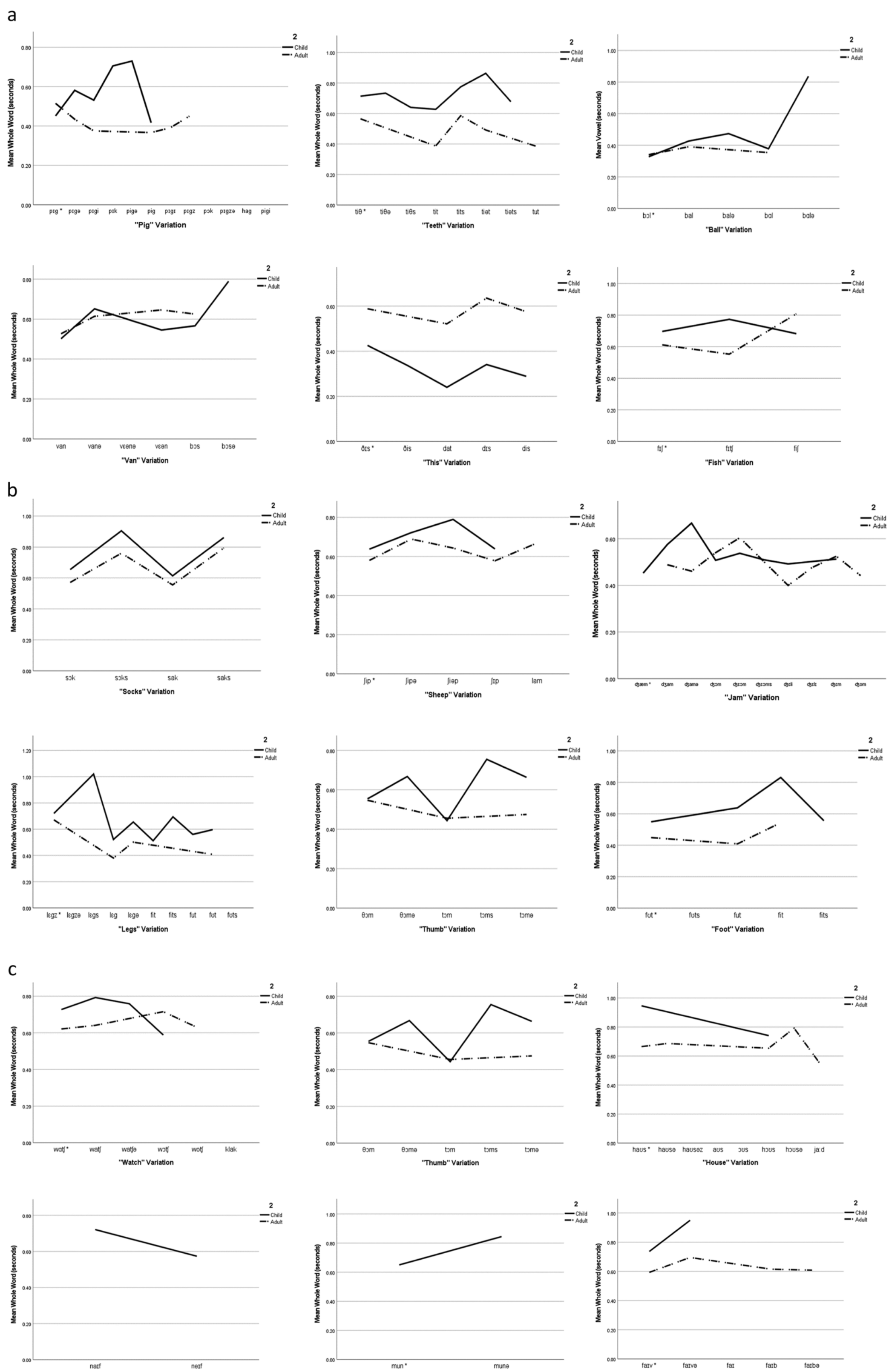
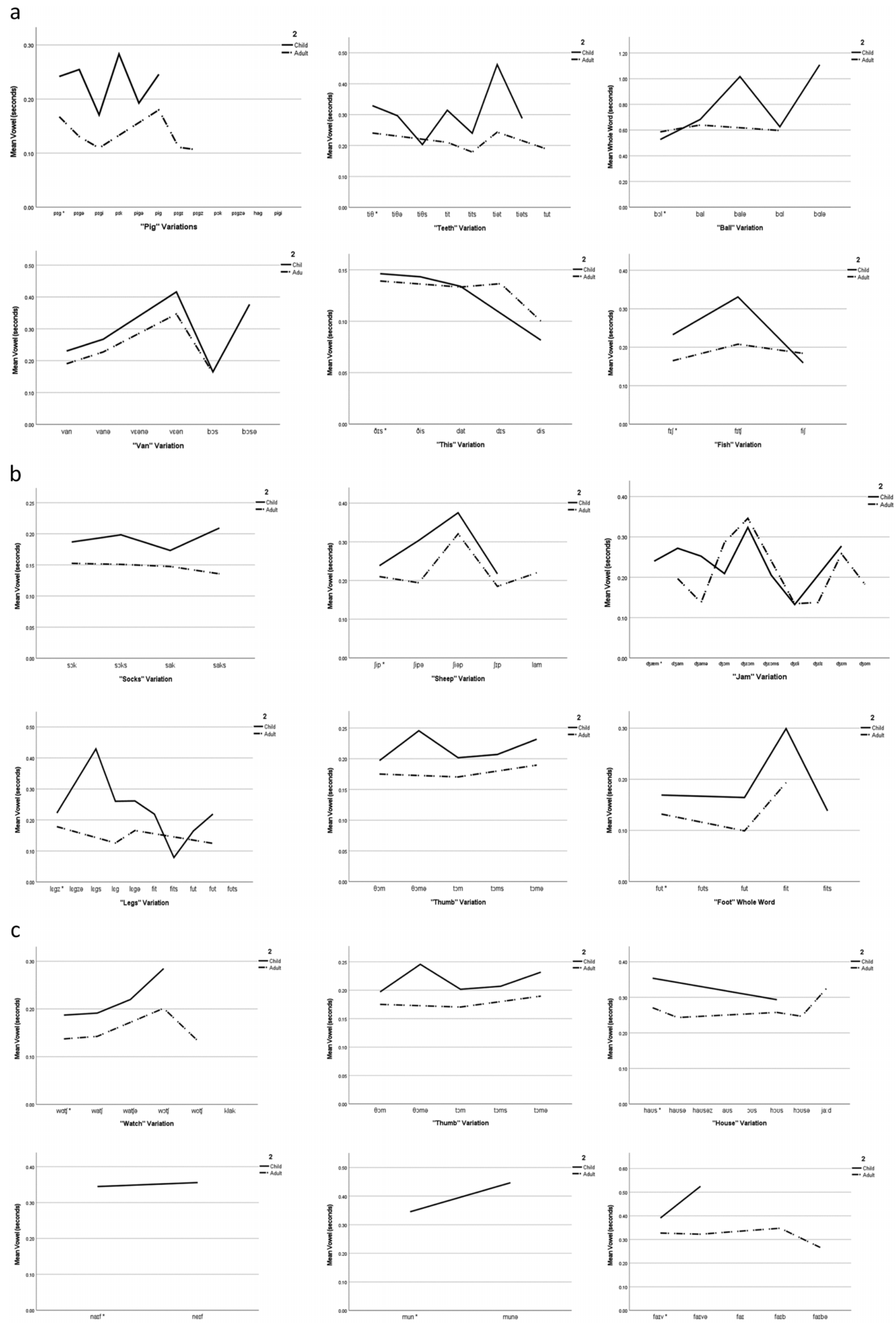


Figure 4. (a, b, c) Mean vowel duration measures between children and adults. Words with asterisks represent the standard/expected production.



First, a multivariate analysis of variance (MANOVA) was conducted to determine differences between child and adult acoustic patterns using the original DEAP Articulation English protocol for whole-word and vowel parameters of duration. Post hoc univariate analysis of variance (ANOVA) models were completed for any significant findings from the MANOVA, with Bonferroni correction for multiple comparisons ($p < .025$). Second, a mixed-model ANOVA for VOT was conducted with speaker (adult, child), voicing (voiced, voiceless), and place of articulation (bilabial, alveolar, velar) as fixed factors. Tukey pairwise comparisons using Bonferroni correction were conducted for significant interaction effects. Otherwise, for all initial models, significance was set a priori at $p < .05$.

For Aim 2, the measures used were PCC-R and word frequencies of responses for children and adults using the standard and adapted protocols. Differences between standard and adapted performance for children and adults were assessed using two Mann–Whitney *U* tests for PCC-R scores. A chi-square test for response frequency for children and adults was also assessed for each protocol. Descriptive data of children's word responses were summarized.

Results

Aim 1: To Investigate Speech Acoustics as a Means to Describe Differences Between Children and Adults in the Jamaican Context

A MANOVA was completed to examine the difference between children and adults on the standard responses to whole-word and vowel acoustic durational measurements. Significant differences were observed between children and adults on the variables of whole-word and vowel duration for three words: "pig" $F(2, 74) = 4.19$, $p = .019$, Pillai's $V = .102$; "fish" $F(2, 111) = 5.81$, $p = .004$, Pillai's $V = .095$; and "this" $F(2, 65) = 8.60$, $p = .000$, Pillai's $V = .209$. The differences were nonsignificant for the remaining words. Follow-up univariate ANOVAs were run for each dependent variable for significant words. For "pig," there was a statistically significant difference between children and adults on whole-word duration, $F(1, 75) = 8.40$, $p = .005$, and vowel duration, $F(1, 75) = 6.08$, $p = .016$. For "fish," there was a statistically significant difference between children and adults on vowel duration, $F(1, 112) = 11.43$, $p = .001$, but not on whole-word duration, $F(1, 112) = 1.68$, $p = .198$. For "this," there was a statistically significant difference between children and adults on whole-word duration, $F(1, 66) = 6.62$, $p = .012$, but not on vowel duration, $F(1, 66) = 0.143$, $p = .707$. Box plots (see Figures 5 and 6) illustrate the distribution of whole-word and vowel acoustic measures for children and adults when using the standard protocol.

A separate mixed repeated-measures ANOVA model was completed for VOT to accommodate for the inclusion of variables relevant to this acoustic measure: speaker (adult, child), voicing, and place of articulation. Levene's test indicated equal variances, $F(8, 91.01) = 2.04$, $p = .051$, when based on median values with an adjusted degrees of freedom. There were significant main effects of voicing, $F(1, 289) = 15.42$, $p < .001$, $\eta_p^2 = .052$, and speaker group (child/adults), $F(1, 289) = 5.57$, $p = .019$, $\eta_p^2 = .019$, on VOT values. Findings revealed a significant two-way interaction for the Speaker × Voicing, $F(1, 283) = 4.33$, $p = .038$. In response to the significant interaction, Cohen's *d* was calculated, with basic rules of thumb for 0.2 indicating a small effect, 0.5 indicating a medium effect, and 0.8 indicating a large effect (Cohen, 1988). Tukey pairwise comparisons with a Bonferroni correction demonstrated a statistically significant mean difference between children and adults for voiced ($p < .001$, $d = 1.62$), but not for voiceless plosives ($p = .503$, $d = .22$). Children produced longer voiced VOT ($M = .027$) compared to adults ($M = -.113$).

Figure 7 illustrates the distribution of VOT for children and adults when using standard target words. Additionally, for illustrative purposes, descriptive statistics (mean values) were generated for all acoustic durational variables for nonstandard productions for children and adult groups (see Figures 2–4).

Aim 2: To Describe Differences in PCC-R and Word Frequencies in a Standard and Culturally Responsive (i.e., Adapted) Protocol in Bilingual Speakers Using Preschooler and Adult Models

Two Mann–Whitney *U* tests were used to determine if differences existed in PCC-R score when using the standard or adapted DEAP responses between children and adults. Distributions of the PCC-R scores were not similar, as assessed by visual inspection, and therefore, mean ranks of each distribution of scores were compared. Using the standard protocol, PCC-R scores for children ($n = 119$, mean rank = 60.06) were statistically significantly different from adults ($n = 15$, mean rank = 126.50), $U = 7.500$, $z = -6.261$, $p < .001$. Using the adapted protocol, PCC-R scores for children ($n = 119$, mean rank = 62.71) were statistically significantly different from adults ($n = 15$, mean rank = 105.50), $U = 322.500$, $z = -4.199$, $p < .001$. To further allow comparison across conditions, descriptive statistics are provided. Adult scores were 100% for both standard and adapted PCC-R. Children's standard PCC-R scores ($M = 87.68$, $SD = 5.29$, $Mdn = 88.24$, range: 70.59–100) were lower than children's adapted PCC-R scores ($M = 97.62$, $SD = 2.85$, $Mdn = 98.00$, range: 81.48–100).

When calculating a Mann–Whitney *U* test, it is possible to calculate *r* using the *r* conversion formula defined as $z/\sqrt{N}$ to allow for an effect size comparison (Grissom & Kim, 2012). *Z* scores from both Mann–Whitney *U* tests were used (standard and adapted PCC-R scores). The interpretation of the *r* correlation coefficient for the standard PCC-R between child and adult was −.54, which is approximately a medium effect size, and the *r* correlation coefficient for the adapted PCC-R score between child and adult was −.36, which is approximately a small effect size (Cohen, 1988).

Chi-square statistics were used to examine the association of frequency of standard target words between children and adults. There was a statistically significant association between children and adults for standard productions of “door” $\chi^2 = 15.876$, $df = 1$, $p < .001$; “this” $\chi^2 = 6.594$, $df = 1$, $p = .010$; and “house” $\chi^2 = 5.080$, $df = 1$, $p = .024$. All expected cell frequencies were greater than five. Fisher’s exact test was used for words with expected cell frequencies of less than five (Blalock, 1972). There was a statistically significant association for standard production of “teeth” ($p < .001$), “car” ($p < .001$), “ball” ($p < .001$), “watch” ($p < .001$), and “five” ($p = .025$). Results were nonsignificant for the remaining words. Another chi-square statistic was used to examine the associations between children and adults for frequency of adapted productions. Results were nonsignificant for all words. Additionally, the frequency of the preschoolers’ response variations is found in Supplemental Material S1, which describes the frequency of standard production and “other” productions.

Discussion

Bilingual populations in the United States are increasing and will result in SLP caseloads being more reflective of this change in linguistic demography (Guiberson & Ferris, 2019). Despite the anticipated growth, communication assessment practices have not kept pace with most assessments being historically developed based on monolingual or majority language speakers, making them less responsive to reducing the potential risk of misdiagnosis in the bilingual population. In this study, this concern was addressed by applying two different protocols and using acoustic and perceptual analyses to determine differences in capturing a wider and, thus, more accurate range of speech sound production of an understudied linguistic group, JC–English speakers. From a total of 119 JC-English–speaking children and 15 JC-English–speaking adults, we first described patterns of single-word productions as guided by the standard English DEAP protocol. Second, we described patterns of single-word duration as guided by an adapted and linguistically informed DEAP protocol. Findings demonstrated that the culturally responsive (i.e., adapted) approach was most effective in capturing a wider range of the preschoolers’ linguistic variation and reflects more accurate representations of speech sound productions.

For Aim 1, the standard productions were used to establish knowledge about differences in acoustic duration measures. Generally, all acoustic duration distributions were longer for children than for adults. Differences in duration were expected, as age has been shown to influence acoustic measures (Katz & Assmann, 2001; Kewley-Port & Preston, 1974; Menyuk & Klatt, 1975; Smith, 1992; Tingley & Allen, 1975), being longer for children than for adults. Interestingly, most differences found in this study were not statistically significant. Limitations related to this observation are expanded upon in the Limitations and Future Directions section below. It should be noted, however, that this lack of difference emphasizes that children’s speech patterns are similar to those of adults and, as such, represent the linguistic pattern rather than errors in production.

The post-Creole continuum reflects British English influences. As such, speakers of JC present with speech characteristics (e.g., phonetic features) that closely align with British English. However, JC is also influenced by American English for different reasons, including viewing American media, migration, and close geographic proximity to the United States (Coy & Watson, 2020; Höhn, 2011). An acoustic characteristic in our participants was the presence of prevoicing (i.e., negative VOT values) in adults for initial voiced plosives. This characteristic aligns closer with British English speakers (Docherty, 2011) than American English speakers (Lisker & Abramson, 1967). Docherty (2011) noted that the acoustic timing of British English speakers varied from prevoicing to short VOT lag in the positive range. This differed from American English speakers that mostly produced short VOT values within the positive range for voiced consonants (Lisker & Abramson, 1967). Contrastively, children evidenced a larger distribution of VOT for voiced consonants that ranged from negative to positive values. A possible explanation for these results can be that prevoicing is a developmentally acquired characteristic in the Jamaican context, suggesting that children may need more time to evidence this linguistic feature.

To offer some contextualization of the acoustic patterns observed, we also included illustrations of the nonstandard variations. It was clear that children and adults produced a number of nonstandard word variations, even when verbally reminded to respond in “English” (see Supplemental Material S1 for children’s responses), reinforcing the ecological validity of production variation in the Jamaican context. To illustrate this observation more clearly, Figures 2a and 2b displayed the mean VOT values for the standard words and the variation of responses produced. Furthermore, Figures 3a, 3b, 4a, and 4b illustrate the mean duration length for words and vowels. As expected, duration measures were longer and more variable for children than adults for whole word, vowel, and VOT. These findings could also be expected for monolingual children (Eguchi & Hirsh, 1969; Hitchcock & Koenig, 2013, 2015; Kent, 1976). Evidence in support of acoustic analyses for the characterization of speech patterns has been suggested to increase our understanding of patterns of typical bilingual speech development (cf. Fabiano-Smith & Bunta, 2012; Ronquest, 2012; Speights Atkins et al., 2017). The findings of this study do not provide sufficient evidence for use of acoustic durational differences in clinical practice for this population. However, we observed that the children's acoustic durational measures resemble adultlike patterns from their linguistic community, and the present variability could indicate motor development. Therefore, it would be of value to compare bilingual children to monolingual speakers and/or General American English speakers. First, as that is frequently the context, bilingual children are judged against in the United States. Second, the comparison would support the distinction of acoustic patterns attributed to motor development from those variations attributed to cross-linguistic effects and, as such, reduce misdiagnosis of speech disorders in bilingual children.

The main objective of Aim 2 was to describe differences in PCC-R and word frequencies of JC-English–speaking children and adults by using the standard and adapted protocols. The adapted protocol was developed using application of knowledge of the shared linguistic foundations of the post-Creole continuum (cf. Meade, 2001; Patrick, 2004; Wassink, 1999). This linguistic knowledge was applied to provide a culturally responsive protocol that accurately informed bilingual speech profiles. Although the adult productions served as the models for the expected standard responses, they did not produce every expected response for the target words in this context. This practice revealed that adults produced typical speech features from the post-Creole continuum, reflecting specific phonological or lexical variations within their repertoire. This finding sheds light on the phonotactic and lexical variations that should also be expected from JC-English–speaking children, even in an English context (Washington et al., 2017, 2019; see also Supplemental Material S1). Furthermore, the presence of these features and the absence of others in adults' productions, including similar durational values, confirm that similar production patterns observed in children should not be characterized as errors. For example, a feature that was frequently observed was epenthesis, that is, the adding of an unstressed vowel in final word position. This feature can be considered a phonological process not typically expected in the mainstream English context after approximately 8 years of age in the United States and other countries, such as Canada. However, in the Jamaican context, epenthesis is a representative phonological feature (Harry, 2006; Washington, 2012). Having an awareness of this linguistic feature is critical in distinguishing between errors and dialectal differences. It was further observed that vowels outside the Jamaican context (e.g., [æ]) were also absent from most participants' speech productions. Although adults did not produce this phoneme, there was a limited production of [æ] by some children. This production practice could be attributed to social contextual influences, such as exposure to American English by the media and/or from speakers in their environment. Important to note is that a perceived distortion or substitution of [æ] can lead to suspicion of speech disorders in the English context (Dodd, 2005). This finding shows that caution should be used when vowel errors are observed in bilingual speakers, especially when the vowel is one which is uncommon or nonexistent in the child's other language.

To further address Aim 2, children's and adults' PCC-R scores were analyzed. The children's mean score for PCC-R scores was higher when using the adapted context (97.6) compared to the standard English-only context (87.7), indicating that the PCC-R score was impacted by the criterion used. The greater number of lower scores in the standard English context can lead to misinterpretation of the children's speech capabilities. The observation of standard protocols being differentially and negatively reflective of bilingual children's communication skills has also been reported in other studies with children who use more than one language on a daily basis. For example, Pearce and Williams (2013) found an overdiagnosis of disorder in language skills using the Clinical Evaluation of Language Fundamentals–Fourth Edition with Indigenous Australian children, and Barragan et al. (2018) found similar results with Spanish–English bilinguals. The reduced accuracy and sensitivity of these standard measures in bilingual contexts is of concern and has been thought to contribute to the disproportionate representation of racial and ethnic groups in special education (Dragoo, 2018).

The absence of significant differences for response frequency, unlike in the English context, supports the notion that the adapted protocol captured (i.e., was responsive to) a wider range of acceptable productions, demonstrating culturally responsive practices. This is an important and clinically relevant finding: standard guidelines, although frequently used, may not be appropriate. To further illustrate the concern with using a standard English protocol, we hypothesized that statistically significant differences using perceptual data (PCC-R and response frequency) were expected as more word variations would be considered "errored" in this context. Perceptual data are often used clinically, and therefore, a difference can have implications for diagnostic misinterpretation of speech disorders. The differences in speech characteristics found in the English context illustrate the need to expand normative data for other populations, especially if patterns do not align with the standard context, echoing recent calls for greater responsivity in practices in linguistically diverse contexts (cf. Guiberson, 2020; Pearce & Williams, 2013).

This study supports previous findings with JC-English–speaking participants and contributes additional examples that suggest word variation may be increased in some language paradigms, such as JC and English (Abu El Adas et al., 2020). Word variation has been considered a key component used in SSD diagnosis (Preston & Seki, 2011), and awareness of this trend may broaden our understanding of variation in the context of languages that come from a post-Creole continuum. Supplemental Material S1 illustrates that for most (60.9%, n = 14) stimulus items, "other" variations were produced at a higher frequency than the "expected" standard English productions. As such, increased likelihoods for word variation of the same target (e.g., [pɪg, pɪgə, pɪgi, pɪgɪ]) may be expected from languages that have a high tolerance for variation and should therefore be considered during assessments. Although Wright Karem and Washington (2021) demonstrated that culturally responsive approaches were most effective when evaluating language capabilities in the Jamaican context, fueling the need for a change in practice, the findings from our study extend this urgency to speech capabilities. Our findings, although not exhaustive, exemplify the application of objective measures in systematically approaching the linguistic variation that exists in this populous. Our findings allow for greater understanding of the variation and are anchored in adults from the same community to inform the variation and speech patterns just developmental in nature. Overall, by using innovative and culturally responsive techniques, this study is a first step in applying objective methods that consider the linguistic variation for describing speech patterns as a means of understanding the developmental profile in the Jamaican context, which can be useful in informing future steps for characterizing children with speech disorders.

Limitations and Future Directions

Similar to other published works, this investigation is not without its limitations. Participants included in this study were located in Jamaica and were all classified as simultaneous bilinguals. Although the sample was largely representative of the population in Jamaica, there exists a diaspora of JC–English speakers in other countries, and therefore, the sample may not be internationally representative. This limits the external validity of the study's findings. As such, it is worthwhile to examine patterns of JC–English speakers outside Jamaica to identify if external contextual factors influence speech patterns and include other bilingual typologies, such as sequential bilinguals, to extend our understanding of bilingual profiles. Furthermore, adults self-reported typical hearing acuity and did not undergo a formal language assessment. Adult participants were mostly female, which may have impacted the word variations produced and the corresponding durational values, particularly VOT values.

A second limitation, relating to the quality of the audio recordings, was that audio recordings were acquired at the children's schools and thus were not recorded in quiet sound booths. However, it has been suggested that recordings in natural environments, or field recordings, capture the speaker in a more familiar context as compared to a recording studio, and therefore, the speech patterns produced in natural environments are more likely to resemble the speakers' natural patterns (Pierce et al., 2021). Additionally, field recordings also offer ecological validity for the characterization of speech patterns that can be useful for clinical practice (Pierce et al., 2021), and our durational measures are relatively impervious to background noise, unlike many other acoustic measures (e.g., spectral measures). As part of the Jamaican Creole Language Project, the field recordings used in this analysis did not include multiple repetitions for each word. Although a relatively large sample size was included, this may have limited the capture of naturally occurring durational variability in individuals, especially for child productions.

We limited our assessment approach to the DEAP Articulation subtest. In following the standardized protocol, there were limited opportunities per vowel context (i.e., one opportunity for [ʌ] vs. 12 for [ɔ]). While expanding to the entire composite of the DEAP and widening the word subset criteria would broaden our knowledge of Jamaican speech characteristics and allow for assessment of more speech sounds, the inclusion of one subtest was sufficient in addressing the main purpose of this exploratory study: to identify how the approaches impacted the resulting speech skillset and, in turn, how they could be interpreted differently. Finally, this study focused on the administration of the assessments in English to allow for a detailed comparison of speech characteristics in the context where misdiagnosis is most likely to occur.

For this initial work, we are providing an understanding of what is representative of the Jamaican community. Future studies on the current topic are, however, warranted. These studies could incorporate the assessment of speech skills in English and in JC contexts. It would also be of value that future investigations compare monolingual children and speakers of General American English to distinguish the impact of cross-linguistic effects compared to motor-based developmental changes.

Furthermore, a comparison with children with SSDs would offer theoretical and clinical value to the existing literature. Future studies should also expand beyond the durational measures analyzed in this study (e.g., segment duration, Shriberg & Wren, 2019; the steady-state portion from the target sound, and slope analysis, Pagan-Neves & Wertzner, 2010, as cited in Wertzner et al., 2017). These additional measures would allow for a broader description of acoustic characteristics in the Jamaican context.

Clinical Implications and Conclusions

This study used a standard and a culturally adapted speech protocol for Jamaican children and adults. Our findings suggested that the culturally adapted protocol was more appropriate for this linguistic context by accounting for more variation that is considered common place in this population. This study provides support for the application of culturally responsive assessment approaches with bilingual children. These approaches allow for a more accurate representation of bilingual children's speech abilities and has the potential to reduce their risk for misdiagnosis of communication disorders. Our study demonstrated that the preschoolers' speech abilities differed negatively when interpreted using a standardized approach compared to a culturally responsive approach (a reduction in PCC on average of 10%), with the use of adult models from the same linguistic community providing confirmatory evidence of typical characteristics.

A wide lexical and phonological repertoire (see Supplemental Material S1) exists in the post-Creole continuum and, therefore, may be produced by typically developing Jamaican children. This information can be used to develop practical changes by accounting for cultural differences (e.g., response variations) through adapted scoring and has been a recommended best practice when working with populations where children use more than one language on a daily basis (McLeod et al., 2017). The characterization of this continuum assists not only in the development of guidelines for adaptive scoring but also in our understanding of the role of increased word and phonotactic variation for describing speech in this context and may be of use in other similar contexts such as divergent use of the standard dialect (e.g., standard English and African American English) or in contexts were languages share extensive cognates (e.g., Spanish and Catalan).

Additionally, the study applied innovative and culturally responsive techniques for characterizing speech by describing linguistically informed acoustic duration measures and perceptual data. Acoustic analysis provides data on physiological, anatomical, and motoric components of speech production that impact speech perception and intelligibility (Kent, 1976; Kent & Rountrey, 2020; Neel, 2010). The findings from this study demonstrated some preliminary evidence of shortened word and vowel duration, along with a pattern of higher incidence of prevoicing in the adult models compared to children's productions. Although we recognize that the variation found in the Jamaican context makes it difficult to develop an objective standard, the results from this study are an important step in characterizing speech patterns with the use of objective methods for assessing bilingual speech. Differences observed between children and adults exist (see Figures 5, 6, and 7), though most were not statistically significant, indicating that children's productions are representative of their linguistic backgrounds. These differences provide some insight into the developmental profile and motor maturity of this population, illustrating that objective acoustic analysis can provide important detail to describe and document speech characteristics in bilingual contexts and confirm that children's speech patterns resemble adultlike patterns at an early age. Although

Figure 5. Whole-word duration by initial phoneme produced in standard English. Extreme outliers > 2 *SD*s not included.

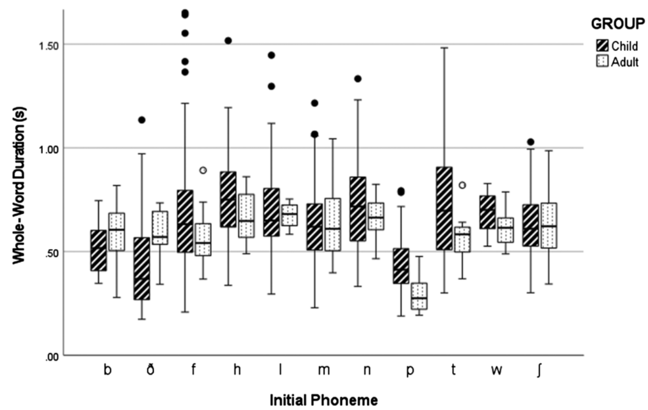


Figure 6. Vowel duration by vowel produced in standard English. Extreme outliers > 2 *SD*s not included.

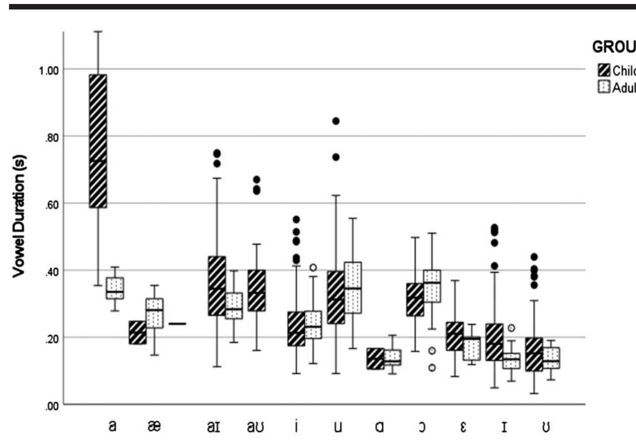
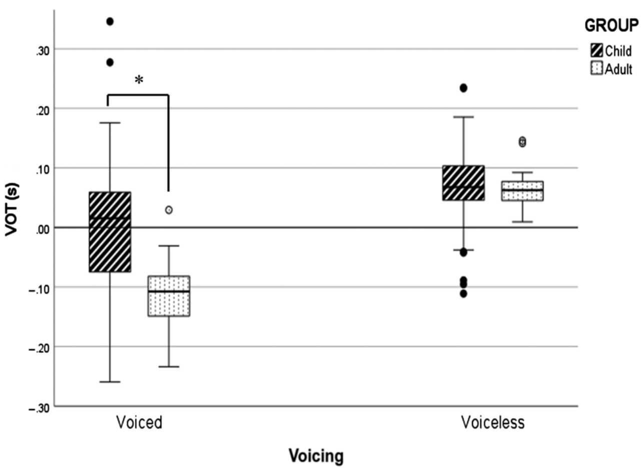


Figure 7. Voice onset time (VOT) of voiced/voiceless plosives in standard English. Extreme outliers > 2 *SD*s not included. *Voiced plosives were significantly longer in children compared to adults ($p < .001$).



caution should be applied to the generalization, these findings can provide precursory knowledge on speech patterns for this population and can strengthen our theoretical understanding of bilingual speech development in Jamaican children to support our clinical decision making and service delivery for improved bilingual diagnostic practices.

Collectively, these findings broaden our knowledge of bilingual speech for an understudied language pairing (e.g., those with shared linguistic foundations). Noteworthy was that the acoustic analysis undertaken has extended our knowledge of the utility of these measures and how they can serve as a basis for future studies seeking to characterize bilingual speech. Our study offers an important step in demonstrating that through the application of a culturally responsive protocol informed by adults from the same linguistic community, we can improve our characterization of speech production for JC-English–speaking children and inform our knowledge of diagnostic practices for speech disorders.

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Appendix

Duration Analysis Protocol

Manner	Onset boundary	Offset boundary
Word duration		
Nasals	Marked at the first pitch period of the low-frequency nasal murmur	Marked at the last pitch period of the low-frequency nasal murmur
Affricates	Marked at the beginning of the high-frequency noise associated with the release burst	Marked at the end of the high-frequency frication noise
Plosives	Marked at the beginning of the high-frequency noise associated with the release burst (first upward-going zero-crossing associated with the spike in energy of the release burst)	Marked at the beginning of the high-frequency noise associated with the release burst
Voice onset time		
Plosives	Marked at the beginning of the high-frequency noise associated with the release burst	Marked at the initiation of voicing of the following vowel (first upward-going zero-crossing of the first phonatory cycle)
	Prevoicing: Marked at beginning of voicing prior to release burst (first upward-going zero-crossing associated with the phonatory cycle)	Marked at the beginning of the high-frequency noise associated with the release burst

Note. Informed by Macrae et al. (2010).