Production of Word-Initial Consonant Sequences by Francophone Preschoolers with a Developmental Phonological Disorder

Séquences de consonnes en position initiale de mot produites par des enfants francophones d'âge préscolaire ayant un trouble phonologique

KEY WORDS

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Abstract

Purpose: The purpose of this pilot study is to describe patterns of word initial consonant sequence errors as produced by 50 francophone children, age 46 to 69 months, who were receiving treatment for a developmental phonological disorder (DPD) in Québec.

Method: The children's productions of consonant sequences on a single-word test of articulation were coded as correct or incorrect and each error type was classified in relation to the 17 types of error described by Chin and Dinnsen (1992) for English-speaking children. Errors were also described in relation to types of consonant sequences as represented in French phonology.

Results: The description of consonant sequence errors by francophone children revealed similarities and differences in comparison to English-speaking children. A high degree of variability was observed across words and participants.

Conclusion: The need to take into account language-specific developmental norms for phonemes and prosodic structures when planning phonology intervention is highlighted in this study.

Abrégé

But : L'objectif de cette étude pilote était de décrire les patrons d'erreurs de production de séquences de consonnes de 50 enfants francophones du Québec, âgés de 46 à 69 mois, suivis en orthophonie pour un trouble phonologique.

Méthodologie : Les productions de séquences de consonnes en position initiale de mot ont été obtenues à l'aide d'un test d'articulation de mots. Elles ont été codées correctes ou incorrectes et chaque erreur a été classifiée selon les 17 types d'erreurs décrites par Chin et Dinnsen (1992) pour les enfants anglophones. Les erreurs ont également été décrites par rapport aux types de séquences de consonnes présentes dans la phonologie du français.

Résultats : La description d'erreurs de séquences de consonnes commises par les enfants francophones a révélé des ressemblances et des différences en comparaison aux enfants anglophones. Une grande variabilité a été observée entre les mots et entre les participants.

Conclusion : L'étude a mis en évidence l'importance de tenir compte des normes développementales spécifiques au français pour les phonèmes et les structures prosodiques lors de la planification de l'intervention orthophonique.

English speaking children are known to have difficulty with the accurate production of consonant sequences early in life regardless of whether their speech is developing within the expected time frame or following a delayed trajectory (McLeod, Van Doorn, & Reed, 1997, 2001b). Given the frequency of occurrence and the great variety of consonant sequences that English phonotactics allow, misarticulations of these sequences can pose a significant challenge to the intelligibility of child speech; therefore it is not surprising that consonant sequences are a frequent speech therapy target (Hodson, 2007; Hodson & Paden, 1981). A large literature on normal and delayed speech development exists to support clinical decision making in the treatment of consonant sequence errors in English-speaking children with a developmental phonological disorder (DPD). When evaluating and treating French-speaking children with delayed speech development however the empirical basis for clinical decision making is impoverished. Diagnostic and treatment planning decisions in phonology sometimes depend in part on a judgment about whether the child's error patterns are typical or atypical (Dodd, 2011). In the francophone context, how does the speech-language pathologist (S-LP) know whether a given consonant sequence error is relatively frequent or rather unusual in comparison to errors produced by other children of the same age? Determining whether a given child should be a high priority candidate for treatment on the basis of atypical error patterns is a clinical decision that requires a greater body of descriptive evidence about speech development in French-speaking children. In this paper we begin with a description of the phonological structure of word-initial consonant sequences and follow with a brief review of consonant sequence production by English- and French-speaking children covering both normal and atypical development. This introduction forms the background for the presentation of new data describing word initial consonant sequence production by 50 francophone children who were receiving treatment for a DPD in Québec.

Phonological Structure of Word Initial Consonant Sequences

Although there are some small differences in the phonotactics of these sequences (see Table 1), French and English both allow words to begin with two or three consonants in addition to null and singleton onsets (Locke, 1983). Generally a word initial sequence of consonants is not considered to be a cluster unless all consonants are contained within the onset of the syllable. The phonological structure of a consonant sequence depends upon the phonetic content and sonority profile of the sequence. Sequences composed of a true consonant followed by a liquid do not violate the Sonority Sequencing Principle (SSP) and are unambiguously true clusters with a branching onset structure as illustrated in Figure 1a. In French, a sequence of a stop followed by a fricative, specifically /ps/, also forms a permitted true cluster although these types of clusters are admittedly low frequency, both within French itself and cross-linguistically (Syrika, Nicolaidis, Edwards, & Beckman, 2011). In English, examples of words that are consistent with the SSP are 'brick', 'play', 'dress' and 'glue' because sonority rises from the first to the second consonant in the sequence with a further rise into the nucleus of the syllable. In French, examples of words that begin with true clusters are 'psychologue' → [psikɔlɔg], 'grosse' → [gʁos], and 'glace' → [glas]. Figure 1a diagrams these French and English words with both members of the initial consonant sequence branching within the onset.

In French and English, two- or three-element sequences involving [s] followed by a stop violate the SSP. Various phonological representations have been proposed for these sequences including the possibility that the /s/ is an adjunct, linked directly to the syllable tier, bypassing the onset itself (Barlow, 2001). This adjunct structure as diagramed in Figure 1b is a possible representation for words such as 'spit'→ [spɪt] and 'splash' → [splæʃ] in English and 'stade'→ [stad] and 'stress' → [stʁɛs] in French. Some linguists propose that the /s/ is an adjunct in all cases regardless of rising, falling, or flat sonority within the sequence (Jongstra, 2003) in which case words such as 'snow'→ [snoʊ] and 'sleep' → [slip] in English would also be represented as shown in Figure 1b (French examples are loan words).

Glide clusters do not violate the SSP; indeed they are interesting by virtue of the large increase in sonority ranking between the first and second consonant in the sequence which reportedly facilitates accurate production (Yavaş & McLeod, 2010). The similarity of the glide to the vowel in the nucleus relative to the obstruent in the onset leaves some ambiguity as to the syllable position of the glide. This is especially true for French which does not have diphthongs and thus the nucleus may be particularly likely to capture the glide (Rose & Wauquier-Gravelines, 2007). Figure 1c shows a representation that would be appropriate for the French word 'doigt' → [dwa]. Although the glide in these sequences may be a rising diphthong within the nucleus in French, various representations have been proposed for English and may be word specific. For example, Kehoe, Hilaire-Debove, Demuth, & Lleó (2008) proposed a true branching onset structure for words such as 'twin' but simultaneous linkage of the glide to the onset and nucleus in words such as 'pew'.

In summary there are a large number of different consonant sequences permitted in both languages. The attendant variety in phonetic content and complexity in underlying phonological representation ensures that the

Table 1. Permitted Word Initial Consonant Sequences by Type in English and French

Sequence Type	English	French
True cluster: (Figure 1a)		
Stop+Fricative		[ps]
Stop+Liquid[a]	[pl] [pɹ] [bl] [bɹ] [tɹ] [dɹ] [kl] [kɹ] [gl] [gɹ]	[pl] [pʁ] [bl] [bʁ] [tʁ] [dʁ] [kl] [kʁ] [gl] [gʁ]
Fricative+Nasal	[sm] [sn]	
Fricative+Liquid	[fl] [fɹ] [θɹ] [sl] [ʃɹ]	[fl] [fʁ] [vʁ]
Adjunct /s/: (Figure 1b)		
Fricative+Stop	[sp] [st] [sk]	[sp] [st] [sk]
Fricative+Stop+Liquid	[spl] [spɹ] [stɹ] [skɹ]	[spl] [spʁ] [stʁ] [skl] [skʁ]
Either true cluster or rising diphthong: (Figure 1c)		
Stop+Glide	[pw] [pj] [bj] [tw] [tj] [dw] [dj] [kw] [kj] [gw]	[pw] [pj] [pɥ] [bw] [tw] [dw] [tj] [dj] [kɥ]
Nasal+Glide	[mj] [nj]	[mw] [mj] [nj]
Fricative+Glide	[fj] [vj] [θw] [sw] [ʃw]	[sw] [sj] [ʃw] [ʃj] [hɥ]
Stop+Liquid+Glide		[bʁɥ] [tʁw] [dʁw]

Note: The lists are not exhaustive as the reader will be able to add additional possibilities representing loan words, onomatopoeic words, or optional sequences (e.g., in English [zl] in 'zloty', [vɹ] in 'vroom' or [lj] in 'lewd'). Some unusual Fricative+Fricative sequences are also excluded from the table (sphinx, svelte) as they represent a flat sonorancy hierarchy although they could be added to the Adjunct /s/ category for both languages. Sources for the data in the table include Le grand Robert de la langue française (version électronique, 2012), Locke (1983), McLeod, Van Doorn, & Reed (2001b), Oxford English Dictionary Online (2013), Rose & Wauquier-Gravelines (2007), Smit (2007), and Walker (1984).

[a]The French consonant [ʁ] is phonetically a uvular fricative but is often classed as a rhotic liquid phonologically (e.g., Dell, 1995).

acquisition patterns for consonant sequences will be far from straightforward and subject to individual differences within and across language groups. We turn now to a brief overview of the developmental literature.

Acquisition of Word Initial Consonant Sequences in English

Acquisition of consonant sequences is constrained by the child's ability to reproduce the prosodic structure and the phonetic content involved. Most two-year-olds can produce some two element clusters in word-initial and word-final positions although the segments will often be misarticulated (Stoel-Gammon, 1987). In an extensive review of the literature, McLeod et al. (2001b) generalized that the normal and gradual developmental progression toward mastery in English begins with omission of one or two segments leaving only one segment in the surface form (i.e., cluster reduction), followed by inclusion of all segments but with one or more being misarticulated (i.e., simplification), culminating in correct articulation of the required segments. Mastery comes earlier for word-final than word-initial clusters, two-element than three-element clusters, and stop than fricative clusters in English. Notwithstanding these generalizations, McLeod, Van Doorn, and Reed (2001a) observed considerable individual variation and many "reversals and revisions" in the developmental trajectories of toddlers observed longitudinally. Smit, Hand, Freilinger, Bernthal, and Bird (1990) reported that the 90% age of mastery for the /s/ and /ɹ/ clusters was between 7;0 and 9;0 reflecting the likelihood of distortion errors for these late developing segments into school age. In a detailed description of error types in a cross-sectional study, reduction to null occurred rarely for all word initial consonant sequences (Smit, 1993). Reduction of two- and

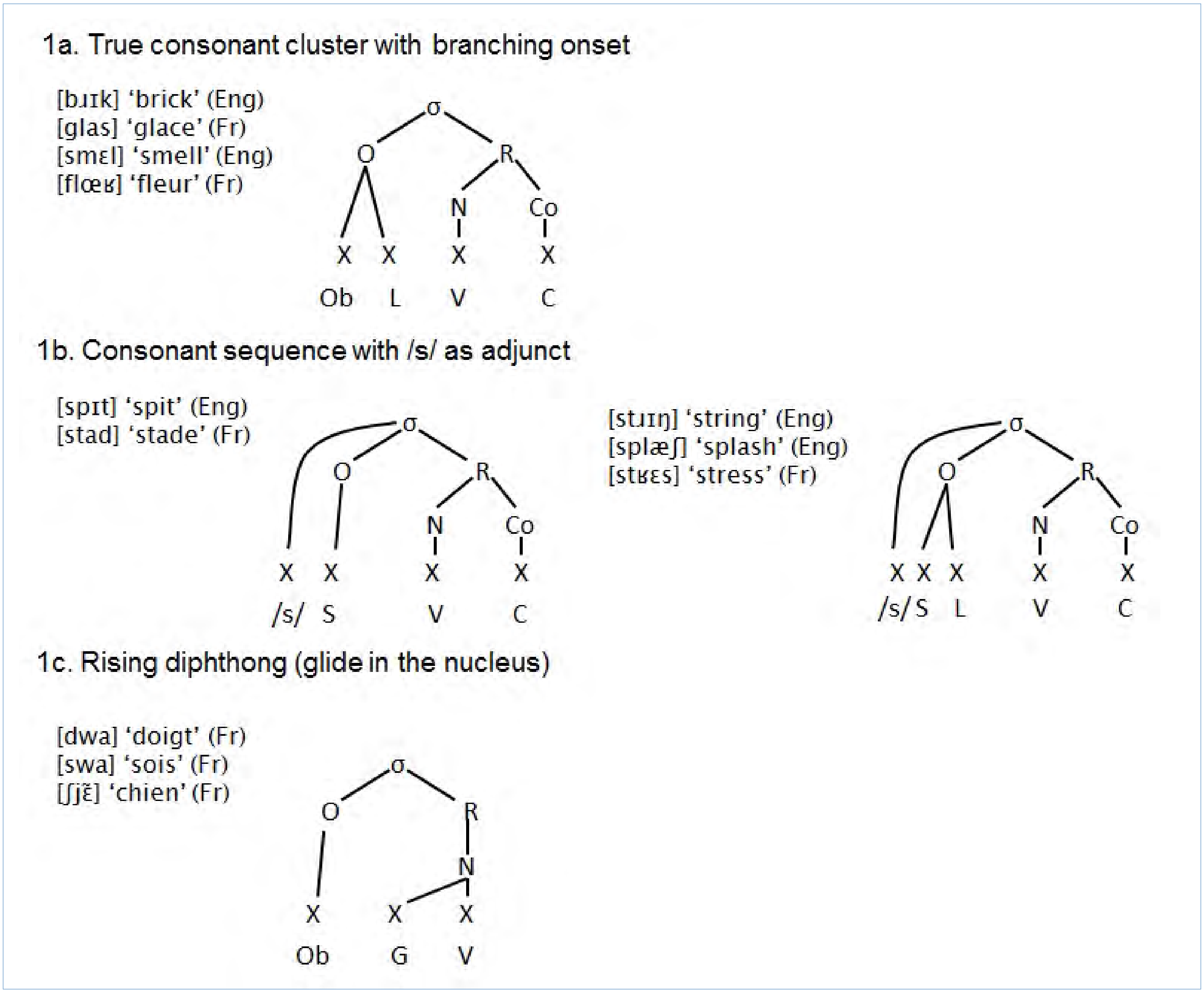

Figure 1. Alternate phonological representations for word initial consonant sequences in English and in French: (1a) True clusters with a branching onset in which the elements in the onset increase in sonority from left to right; (1b) /s/ represented as an adjunct that links directly to the syllable tier, bypassing the onset, due to the violation of the Sonority Sequencing Principle in the consonant sequence; and (1c) glide represented as part of a branching nucleus. Abbreviations: σ = syllable, O = onset, N = nucleus, R = rime, Co = coda, X = time unit for a segment, Ob = obstruent, S = stop, L = liquid, V = vowel, and C = any consonant, Eng = English and Fr = French.

three-element sequences to a single segment occurred no more than 15% of the time in children older than 3;0, with the exception of certain /s/ clusters. Porter and Hodson (2001) also reported a marked decline in the reduction of consonant sequences after age 3;0. Occasional instances of cluster reduction persist through age 5;0 however (Cahill Haelsig & Madison, 1986) and omissions of segments from consonant sequences in complex words persist into school age (James, van Doorn, McLeod, & Esterman, 2008).

Chin and Dinnsen (1992) described children's underlying phonological representations for word-initial consonant sequences in a study in which 47 preschoolers with speech delay produced 49 different stop and fricative clusters. They observed 17 different patterns of error at the surface level including complete omission of the sequence, reduction, simplification, epenthesis, and coalescence. The authors subsequently described the emergence of these patterns in terms of interactions between the feature and prosodic levels of the phonological hierarchy in the children's phonological systems. For example, coalescence can occur when the child's system is constrained to single element onsets in the output but the features of both elements are represented underlyingly: spreading of a feature from one segment to another within an onset followed by delinking of one segment results in coalescence errors such as 'sweet'→ [fit]. Coalescence occurs when a marked feature from one segment spreads to a segment that is unmarked; in the 'sweet' example, /w/ is marked by virtue of [Labial] place whereas /s/ is unmarked for place which explains the vulnerability of /s/ clusters in English to spreading and coalescence errors. Other clusters in which both segments have marked place features (e.g., /gɹ/) are theoretically invulnerable to these types of errors. However it is necessary to take the child's underlying representations for the given segments into account. If the child's system lacks dorsal stops and the child's underlying representation for the second segment is /w/ a coalescence error may occur on this sequence resulting in 'growing' → [bowɪn] (Barlow, 1996).

Acquisition of Word Initial Consonant Sequences in French

Considerably less information is available regarding the normal acquisition of consonant sequences by French speaking children. In the only large sample investigation of children speaking Québec French, MacLeod, Sutton, Trudeau, and Thordardottir (2011) probed production of 10 consonant sequences. The participants were 156 francophone children aged 20 to 53 months. The consonant sequences included six sequences comprising Obstruent+Liquid (/l/ or /ʁ/), 1 three-element sequence with an /s/ adjunct, and 3 rising diphthongs. Acquisition age by 75% of the sample was noted for each sequence. Although these consonant sequences were acquired later than consonant singletons, all except word final /bʁ/ were acquired before 48 months of age. Word initial /l/ clusters were the earliest sequences to be acquired.

Rose (2000) reported on the basis of data from two children that early development of true clusters in French always begins with reduction to a single consonant with the obstruent retained and the liquid deleted from the surface form. Inclusion of the liquid emerges earlier in stressed than unstressed syllables. Kehoe et al. (2008) reported that acquisition order for branching onsets and rising diphthongs was complex with much individual variation and segmental content of the sequences playing a large role. Many of the 14 toddlers in their sample acquired Obstruent+/l/ sequences before rising diphthongs and showed the longest acquisition trajectory for Obstruent+/ʁ/ sequences. Rising diphthongs with /w/ were often although not always acquired earlier than those with /j/.

Thus far investigations of consonant sequence production by francophone children have been few, typically involving small samples of participants with normally developing speech. The studies have tended to focus on linguistic controversies regarding the representation of consonants and consonant sequences in word final position. Very little is known about typical and atypical patterns of error with respect to word initial consonant sequences in French, which are, in contrast to English, learned first (Demuth & Kehoe, 2006; Demuth & McCullough, 2008). The purpose of this pilot study was to describe patterns of word initial consonant sequence error as produced by 50 francophone children who were receiving treatment for a DPD in Québec. The errors will be described in relation to what is known about patterns of error in the speech of English-speaking children as described by Chin and Dinnsen (1992) and in relation to types of consonant sequences as represented in French phonology (Rose, 2000).

Method

Participants

The participants were 50 French-speaking children who were referred by Speech-Language Pathologists (SLPs) at the Montreal Children's Hospital for participation in a study investigating the effectiveness of interventions to improve the phonological skills of children with DPD. The children were assessed by the third author, a certified S-LP, or by graduate S-LP students under the supervision of the third author. The assessment sessions took place either in a quiet room at McGill University or in a testing room at the Montreal Children's Hospital. The selection criteria were as follows: age 4;0 to 5;11, French-speaking with no more than 25% exposure to another language as determined by parent report, standard score of at least 80 on measures of non-verbal intelligence and receptive vocabulary, normal hearing as documented prior to referral to the study, and primary diagnosis of DPD. Exclusionary criteria included the presence of sensory-neural hearing loss, cleft palate, global developmental delay, autism spectrum disorder, or other medical conditions that could lead to a secondary DPD. Children with suspected childhood apraxia of speech or concomitant receptive and/or expressive language impairments were not excluded from the study. The first 50 children who were referred and who completed the assessment were selected for inclusion in this study. These children were aged 46 to 69 months with a mean age of approximately 54 months (4;6). The socio-economic status of the families varied with maternal education in years ranging from 10 to 18. The children were recruited from the Montréal area of Quebec, which (according to the 2006 census, Statistics Canada, 2009) can be partitioned into 66% francophones, 12% anglophones and 13% allophones. Not only is the majority language French, school attendance in French is required by law for most children and low-cost public daycare is provided in French by the provincial government to families regardless of family income and the vocational status of the child's parents. Within the sample recruited for this study, 72% were reported to have only French exposure while the remaining children were exposed to one or more additional languages in the home up to 25% of the time. The children also attended daycare which, with one exception, provided 100% exposure to French.

Procedures

The children participated in an intake assessment lasting approximately 90 minutes during which time a number of standardized and unstandardized tests were administered and the accompanying parent completed several questionnaires about the child's development and the home literacy environment. Four to six weeks after the intake assessment a conversational speech sample was recorded. Data from four assessment procedures will be described in this report. Specifically, the nonverbal subtest of the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 2004) was administered to ensure eligibility for participation in the study. The Échelles de Vocabulaire en Images de Peabody (Dunn, Theriault-Whalen, & Dunn, 1993) was administered as a normed Canadian-French measure of receptive vocabulary. Percent Consonants Correct in conversation (Shriberg & Kwiatkowski, 1982) was derived from language samples obtained using the wordless book *Good dog,* Carl by Alexandra Day.

The Test Francophone de Phonologie (TFP; Paul & Rvachew, unpublished), as described in Paul (2009), was used to assess accuracy of consonant production. This test contains 54 target words selected to be representative of the distribution of phonemes, syllable shapes, and word lengths characteristic of Québec French. Although a total of 161 consonants and 107 vowels are targeted with the full 54 word sample, only a subset of words is considered in the analyses reported here. Specifically, the children's productions of words containing word initial consonant sequences were selected for further analysis: 'clown', 'glissade', 'fleur', 'brun', 'train', 'traineau', 'crayon', 'graffigner', 'framboise', 'doigt', 'cuisine', 'spectacle'. Spontaneous productions of the targets were elicited using photographs and carrier phrases; delayed or direct imitation was used when necessary to collect full data sets from each participant.

Each assessment was videorecorded with a JVC Everio GZ-MG360 or a Sony Handycam HDR-XR520 videocamera (Dolby digital 5.1 sound recording systems). Audio files were extracted from the video recordings and saved as .wav files. Narrow phonetic transcriptions of the participants' responses on the TFP were completed by the third author, who reviewed each file at least three times. If a child produced the same target more than once, the clearer recording was transcribed; if productions of the same target were equally clear the first one was transcribed. One graduate student in speech-language pathology and one undergraduate student in linguistics each completed narrow phonetic transcriptions of 16% of the TFP samples independently. Transcription agreement with the third author for narrow transcription of the target consonants on the TFP was 94% (range = 89% to 97%). Subsequently the second author coded each consonant sequence production as correct or incorrect and classified each error type in relation to the 17 types of error described by Chin and Dinnsen (1992) for English-speaking children.

Results

Summary of Test Results

The results of the intake assessments are shown in Table 2 and confirm that the children presented with age appropriate nonverbal intelligence and receptive vocabulary skills. On average their mean length of utterance was 4.40 (ranging from 2 to 10), which can be compared to an expected range of 3.85 to 6.45 for normally developing francophone children of this age (Thordardottir, Keheyia, Lessard, Sutton, & Trudeau, 2010). A normative reference for the two measures of articulatory accuracy is lacking but their performance in conversation and while naming pictures indicated that all of the children produced numerous consonant misarticulations that explained the speech intelligibility problems that led to their referral for speech therapy. Percent Consonants Correct was somewhat higher in conversation (77%) than on the picture naming test (70%), reflecting the self-selection of easier words by the children in conversation versus sampling of multisyllabic words by the formal test. Percent Vowels Correct (93%) was high while picture naming.

Summary of Consonant Sequence Accuracy by Word

The children's responses to each item are shown in the Appendix. Figure 2 represents the percentage of correct responses for each word for the monolingual and multilingual subsamples. This figure reveals a tendency toward a greater number of correctly produced sequences for the multilingual subsample ($M = 8.47$, $SD = 3.02$) in comparison to the Monolingual subsample ($M = 6.20$, $SD = 3.64$), a result that is intriguing and worthy of further investigation with larger and more balanced samples of language groups. The overall profile of responses across words is roughly similar for the two language subsamples however and a nonparametric comparison of the median scores for these two subsamples revealed nonsignificant differences (monolingual exposure median = 5, bilingual exposure median = 7, $p = .32$).

When considering the full sample of 50 children, every child misarticulated at least one sequence with a mean of 5.52 ($SD = 3.55$) sequences misarticulated. Table 3 summarizes overall accuracy of production for each of the consonant sequences in the 12 words selected from the TFP, organized

Table 2. Summary of Intake Test Scores

Test	Minimum	Maximum	Mean	SD
Kaufman Brief Intelligence Test (Nonverbal)	86.00	127.00	104.66	10.55
Échelles de Vocabulaire en Images de Peabody	80.00	131.00	100.66	19.65
Mean Length of Utterance	2.00	10.00	4.40	1.54
Percent Consonants Correct in Conversation	44.86	96.49	76.96	10.12
Test Francophone de Phonologie - PCC	42.80	86.30	70.29	11.58
Test Francophone de Phonologie - PVC	74.80	100.00	93.13	5.76

Note: PCC is percent consonants correct and PVC is percent vowels correct.

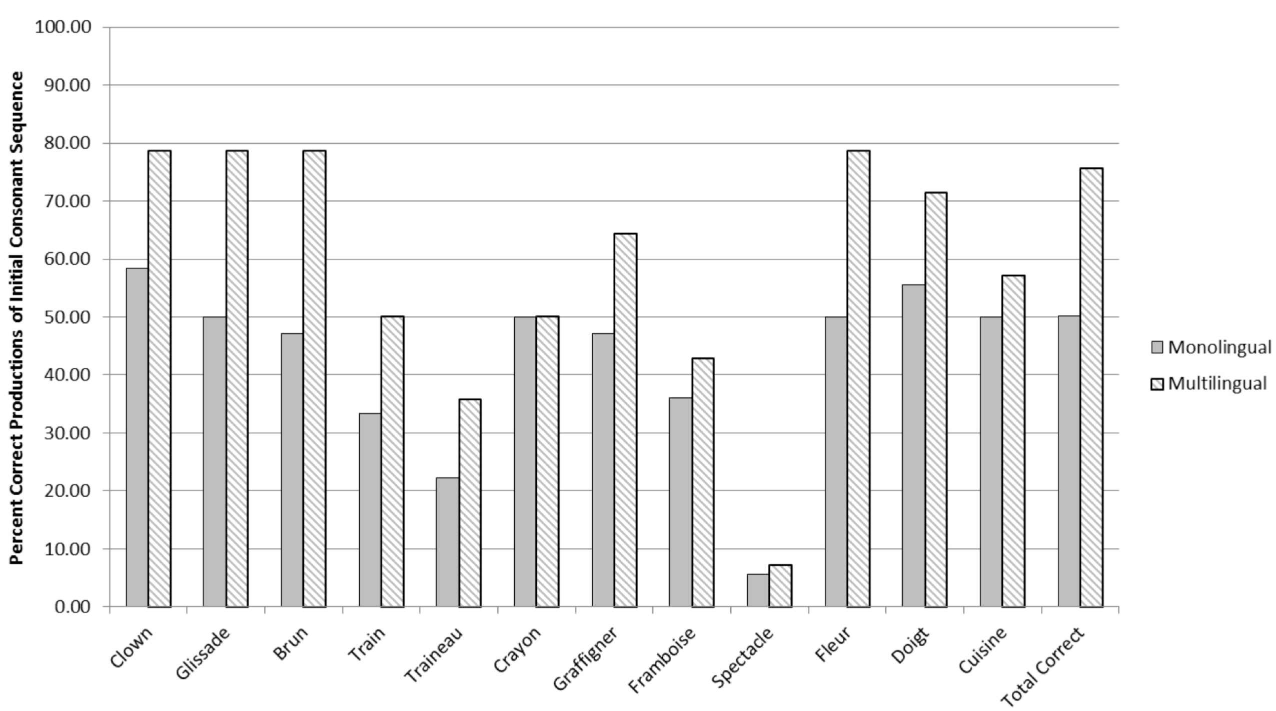

Figure 2. Percent correct production of word initial consonant sequences by word and total as a function of language exposure, specifically Monolingual (only French exposure, grey bars) versus Multilingual (primarily French but 5 to 25% exposure to one or more other languages at home, hashed bars).

Table 3. Number and Percent Correct Production of Word Initial Consonant Sequences by Type

Word	Number Correct	Percent Correct	Subtotal
Branching Onset–Obstruent+/l/			
Clown [ˈklun] (clown)	31	62	
Glissade [gliˈsad] (slide)	29	58	
Fleur [ˈflœʁ] (flower)	29	58	
Subtotal			59
Branching Onset–Obstruent+/ʁ/			
Brun [ˈbʁœ̃n] (brown)	28	56	
Train [ˈtʁɛ̃] (train)	17	34	
Traineau [tʁɛ̃ˈno] (sled)	13	26	
Crayon [kʁɛˈjɔ̃] (crayon)	26	52	
Graffigner [gʁafiˈɲe] (scratch)	26	52	
Framboise [fʁɑ̃ˈbwaz] (raspberry)	19	38	
Subtotal			43
Adjunct /s/			
Spectacle [spɛkˈtakl] (show)	2	4	
Subtotal			4
Rising Diphthong			
Doigt [ˈdwa] (finger)	30	60	
Cuisine [kɥiˈzin](kitchen)	26	52	
Subtotal			56
Total Correct		46	46

Note: PCC is percent consonants correct and PVC is percent vowels correct.

according to type of sequence. Aggregating across children and targets, 46% of the consonant sequence targets were articulated correctly. Percent accuracy was highest for the three items beginning with an obstruent + /l/ sequence ('clown', 'glissade', 'fleur') and the two items involving a rising diphthong ('doigt', 'cuisine'). Variability was high within the group of obstruent + /ʁ/ items with scores ranging from a low of 26% for 'traineau' to a high of 56% for 'brun'. All but two children were unable to produce the /sp/ sequence correctly in the word 'spectacle'. Table 2 presents the data separately for the children who experienced mono- versus multilingual language exposure but there is no evidence of differential responding for these two subsamples. Nonparametric testing to assess differences in median scores indicated no differences for numbers of correct responses to /l/-clusters (2 vs. 3, p = .24), /ɹ/-clusters (3 vs. 3, p = .79), and glide-sequences (1 vs. 1, p = .95) with medians shown for the mono- versus multi-lingual exposure subsamples respectively. Overall there is some evidence of an effect of either word length or syllable prominence as accuracy is higher for word initial consonant sequences in single-syllable (54%) compared to two-syllable (40%) words; the difference in accuracy for the /tʁ/ sequence in 'train' versus 'traineau' is particularly suggestive of a syllable prominence effect. Further investigation with word medial sequences is required to confirm this impression.

Percent Occurrence of Error Types

When describing the productions of English-speaking children with DPD, Chin and Dinnsen (1992) identified 17 types of errors involving consonant sequences with a stop or a fricative in the first position of two element sequences. Table 4 reports the percent occurrence in this francophone sample for the same error types in comparison to the percent occurrence reported in Chin and Dinnsen. It is not possible to match our subjects to Chin and Dinnsen's sample specifically because the English sample was not identified according to severity levels using any normed procedures and no normed procedures exist to objectively describe the speech delay of the children described in this report. However, both samples represent a moderately large sample of preschool aged children receiving treatment for primary speech delay with fairly broad and overlapping age range and thus the comparison of the overall pattern of error

Table 4. Percentage Occurrence of Error Types for Francophone Children Compared to Anglophone Children

C1 Target	C1	C2	French Example	% Occurrence (French/ Mono/Multi)	English Example	% Occurrence (English)
S	✓	✓	[gʁafiɲe] "graffigner"	39.1 35.9 44.1	[prei] "pray"	10.1
S	✓	Ø	[kun] "clown"	14.8 17.1 7.7	[pei] "play"	13.5
F	✓	✓	[floeʁ] "fleur"	8.7 7.6 10.7	[stov] "stove"	6.1
F	Ø	✓	[pɛstak] "spectacle"	8.3 8.1 8.1	[pun] "spoon"	7.6
S	×	✓	[kʁɛ] "train"	6.0 6.0 5.4	[droin] "growing"	2.4
S	✓	×	[twɛno] "traineau"	5.4 5.6 4.8	[pwei] "pray"	13.2
S	Ø	×	[joẽ] "brun	5.1 5.6 4.8	[ɸu] "pew"	9.4
F	✓	Ø	[foeʁ] "fleur"	3.2 3.7 1.8	[sip] "sleep"	4.8
S	Ø	✓	[lun] "clown"	3.2 2.3 5.4	[rei] "pray"	0.7
S	×	×	[twɛjɔ] "crayon"	2.2 2.1 2.4	[fwihaʊs] "treehouse"	3.1
F	Ø	×	[bɑ̃bwaz] "framboise"	1.9 1.4 3.0	[fɪm] "swim"	13.9
F	×	✓	[s̪lɑ] "fleur"	1.5 1.9 0.6	[θta] "star"	6.3
F	✓	×	[fwoew] "fleur"	1.2 1.6 0.0	[stai] "sky"	2.1
S	Ø	Ø	[isad] "glissade"	0.9 0.9 0.6	[ei] "play"	0.4
F	Ø	Ø	[ɑ̃bwaz] "framboise"	0.5 0.5 0.6	[ʊn] "spoon"	0.9
F	×	×	[kwɑ̃bjaz] "framboise"	0.2 0.2 0.0	[fwip] "sleep"	4.4
S	✓	V+ ✓	No examples	0.0 0.0 0.0	[gewin] "queen"	0.1

Note: French data derived from the children described in this report, shown first for all 50 children, then the 36 monolingual children and then the 14 children with multilingual exposure. English data extracted from Chin and Dinnsen (1992) which describes production of consonant sequences by 47 anglophone children with speech delay. Abbreviations in the table are S = any stop consonant, F = any fricative consonant, C1 = the first segment in a 2-element consonant, sequence, C2 = the second segment in a 2-element consonant sequence, Ø = deletion of the consonant, ✓ = correct production of the consonant, and × = misarticulation of the consonant types seems reasonable although close attention to specific percentages of errors is probably not prudent.

The table is organized in descending order of occurrence for the French sample. In French and in English the most frequently occurring production pattern is correct articulation of stop clusters although these sequences were produced correctly with four times greater frequency in French than the English group, reflecting greater frequency of liquid gliding among English-speaking children. In both groups, reduction of stop clusters to the stop in C1 position was the second most frequently occurring pattern. With respect to fricative clusters, correct production ties for fourth place although there is a strong tendency to reduce these clusters to the C2 segment in both language groups. Reduction to a single segment was a common pattern in both language groups; in general however, this error pattern occurred more frequently in the English study than among our francophone sample. The remaining patterns occurred in low frequencies in both language groups although there are two differences that will receive further attention in the discussion: a different distribution of spreading errors across targets by language group, and the complete absence of epenthesis in the French group.

Discussion

Correct production of consonant sequences is challenging for children whose speech is developing at a normal or delayed rate. None-the-less, two-element consonant sequences (with the possible exception of /θɹ/) are achieved by 75% or more of English-speaking children between the ages of 3;6 and 6;0 (Smit et al., 1990). Word-initial two-element consonant sequences are acquired by 75% or more of French-speaking children between the ages of 30 and 47 months (MacLeod et al., 2011). Furthermore, smaller sample studies have shown that word-initial sequences are acquired earlier than word-final sequences by French-speaking children, opposite to the developmental pattern for English (Demuth & Kehoe, 2006; Demuth & McCullough, 2008). In contrast to these findings for children with typical speech, Hodson and Paden (1981) reported pervasive cluster reduction among English-speaking children with unintelligible speech; in fact, 100% of their sample aged 3- to 8-years reduced clusters in an object naming task. The French-speaking children in this study produced only 46% of consonant sequences correctly and all 50 children misarticulated at least one word initial consonant sequence. Patterns of consonant sequence production by the francophone children observed in this study share similarities and differences with patterns described in other reports for English-speaking children.

It is commonly reported that cluster reduction is the most frequent error pattern produced by English-speaking children with DPD when attempting consonant sequences (Chin & Dinnsen, 1992; Hodson & Paden, 1981; Yavaş & McLeod, 2010). In Table 4 it can be seen that reductions to a single segment occurred 50% of the time in Chin and Dinnsen's anglophone sample and 37% of the time in our francophone sample. The French-speaking children produced a higher proportion of consonant sequences completely correctly, reflecting earlier acquisition ages for the constituent segments. Even among children with moderate to severe DPD we have found that francophone children have complete phonetic repertoires and are capable of articulating phonemes such as /s/, /k/, /l/ and /ʁ/ correctly (Brosseau-Lapré and Rvachew, 2013).

Yavaş and McLeod (2010) reported that /sp/ was the most difficult consonant sequence for their English-speaking sample to produce correctly, a finding that is mirrored in our results although our finding must be considered with some caution given that we only sampled it in one word with a difficult word shape, 'spectacle'. None-the-less, this was the only sequence that was almost always reduced with 48/50 children producing this sequence as /p/. In another similarity to children speaking English and other languages, reductions most frequently involved deletion of the most sonorant segment in the sequence. However, retention of the least sonorant segment was not consistent and there was variability within and across words and children. For example, for the word 'klun'→ [klun], nine children reduced the word initial sequence to a stop whereas a tenth child reduced the sequence to [l]; on the other hand, for the word 'train'→[tʁɛ̃], six children produced the word with a stop in the onset, five produced it with [ʁ] in the onset and one began with the glide [j]. Looking at individual children, approximately one fifth of the children were inconsistent in their choice of segment to retain while the remainder of the children retained the least sonorant segment (no child retained the most sonorant segment on a consistent basis). These kinds of individual differences have been attributed to developmental changes in the prosodification of individual words with the prosodic structure of different sequences and the nature of the individual segments in the word playing a role in the child's changing phonological representations with age (Jongstra, 2003).

Another reduction pattern that is very common in English data is substitution of a third segment for the target segments in the sequence. This pattern, which occurred 23% of the time in Chin and Dinnsen (1992), was attributed in most cases to coalescence. A related pattern occurs when features from the second segment are spread to the first but no segments are deleted. Altogether these two patterns were somewhat common in our sample but not as frequently occurring as in English with a combined total of 14%. Smit (1993) observed occasional instances of coalescence and spreading errors for /s/+stop sequences among normally developing children through age 5;0. Yavaş and McLeod reported rates of coalescence for sequences involving /s/ by English speaking children with DPD. Reduction was most often observed for /sp/ sequences and coalescence was observed for approximately one-third of the reductions. In contrast, our francophone sample did not produce any coalescence or spreading errors for the /sp/ sequence that was sampled in this study. The only word sampling /sp/ was a particularly difficult word however ('spectacle'→[spɛktakl]). Further sampling with additional /s/ sequences in less difficult words may reveal instances of coalescence in French.

In English, /w/-clusters tend to be acquired relatively early but when they are misarticulated they show particular vulnerability to spreading and coalescence errors among children with normally developing and delayed speech (Smit, 1993; Yavaş & McLeod, 2010). We observed spreading or coalescence errors on 18% of the 'doigt' productions, constituting one-third of all the errors. These errors involved spreading of Labial in four cases (e.g., [pa], [fwa]) and spreading of Dorsal in the remaining five instances (e.g., [ga], [gwa]), reflecting the dual place features for the glide. However, we observed an even higher rate of coalescence and spreading errors on the stop + rhotic cluster /tʁ/ in the words 'train' and 'traineau', specifically 37% of all productions of these words. In every single case, these errors involved spreading of Dorsal from the second segment to the first within the cluster, even for those few children who substituted [w] for /ʁ/. Surprisingly, spreading occurred for the /fʁ/ cluster as well despite the Labial fricative in the first segment position; again it was the place feature Dorsal that spread yielding [gɑ̃bwaz] in one instance, [kwɑ̃bjaz] in another, and seven productions of [kʁɑ̃bwaz].This finding suggests that these children uniformly represent the /ʁ/ as having Dorsal place. Rose (2000) described one child whose /ʁ/ segments were subject to spreading and another whose /ʁ/ segments triggered spreading. Rose asserted that /ʁ/ is placeless in Québec French and concluded that the second child, "mislead by the uvularity of target [ʁ], incorrectly assigns a Dorsal specification to this consonant" (p.24). However, spreading of Dorsal from /ʁ/ to /t/ by 80% of the children in our sample suggests that Dorsal is the preferred specification.

Overall the most striking characteristic of the error patterns observed in the data set is the degree of variability across words and subjects in the production of the consonant sequences. Rvachew and Brosseau-Lapré (2012) describe phonological development in terms of increasing linkages between and self-organization of accumulating representations in the acoustic-phonetic and articulatory-phonetic domains. When phonology is seen as an emergent property of the child's experience with the phonetic properties of the language, word-specific variation and gradual change that includes "reversals and revisions" is to be expected. Adult perception and production of second language consonant sequences has also been described as arising from "language specific phonetic knowledge" (Davidson & Shaw, 2012) that results in very specific patterns of confusion that depend on the segmental content of a given consonant sequence. Phonological, acoustic, and articulatory influences will be considered as explanations for the patterns of consonant sequence articulation observed in this sample of francophone children.

In terms of phonological influences, these largely manifested themselves at the prosodic level in that the clearest indication of a predictable pattern occurred for the /sp/ sequence in the word 'spectacle'. Almost invariably the children reduced this sequence to the least sonorant segment [p] and production accuracy was extremely low relative to the other words elicited. This error pattern has been described as the most common realization of the /s/+stop sequences in the word initial position in English (Smit, 1993) and in Greek (Syrika, et al., 2011). There are a number of proposals suggesting that children may change the underlying prosodification of consonant sequences with development and that sonority profile plays a role in the order in which different clusters achieve adult prosodic structure (see for example, Jongstra, 2003; Rose, 2000). It appears that all of the children described in this report represent 'spectacle' with the /p/ as the head of the first syllable and the /s/ not prosodified. This conclusion is supported by consistent reduction and a complete lack of coalescence for this sequence. The qualitative and quantitative differences in production pattern for this sequence relative to the others support the hypothesis that the /sp/ sequence is not represented as a true cluster.

On the other hand, there was no evidence of qualitative or quantitative differences in the treatment of the /l/-clusters, /ʁ/-clusters, or glide-clusters by these children. All of these sequences were subject to reduction or simplification with spreading between segments occurring with noticeable frequency. The lack of marked differences in production patterns for these sequences may or may not have any bearing on the question of whether the glide sequences should be represented as rising diphthongs. In Rose (2000) this argument was made on the basis of longitudinal data and different time courses for the acquisition of true clusters versus the rising diphthong. In this report we have not presented longitudinal data.

A final issue that pertains to phonological representations for prosodic structure is the complete absence of epenthesis in the francophone sample. Although rare in Chin and Dinnsen (1992), productions such as 'queen' → [gəwin] did occur with 1% frequency. In our sample these constructions were not attested and indeed not expected since vowel epenthesis would, in French, require creation of a second syllable of approximately equal length to the final stressed syllable, an output that would be very dissimilar to the input. Kehoe et al. (2008) did observe rare instances of epenthesis in rising dipthongs among their sample of 1- and 2-year-old children speaking Continental French. The example they provided was 'avion' [a.ˈvjɔ̃] →[avi.ˈɔ̃]. In our study, involving older children albeit with delayed speech development, the rising diphthongs were generally the easier items and epenthesis was not observed. For clinical purposes, epenthesis can be considered to be an atypical error in English and French but in French even more so.

Spreading and coalescence errors may reflect the child's perceptual knowledge of /w/ and /ʁ/ in stop+glide and stop+rhotic sequences. It is well established that children weight dynamic cues more heavily than static cues when identifying place of articulation for consonants in simple and complex onsets (Nittrouer, Crowther, & Miller, 1998). The acoustic-phonetic features of the second segment in sequences such as /tʁ/, /fʁ/, and /dw/ are likely to be particularly salient to the child listener. Furthermore, coarticulation of the segments obscures some of the cues to the first segment (Byrd, 1996; Davidson & Shaw, 2012) which further supports assimilation of features of the second segment to the first segment in the sequence.

With respect to the influence of articulatory knowledge, the greatest accuracy was observed for clusters consisting of segments that were well established in the children's repertoire. The /l/ clusters, especially in the word 'clown', and the glide sequences were well articulated, as also observed for French-speaking toddlers by Kehoe et al. (2008). The earlier acquisition of all of the segments involved in general explains the higher accuracy rate for consonant sequences for French-speaking children with DPD compared to English-speaking children with DPD in previously published reports. Sequences involving fricatives and the rhotic /ʁ/ were subject to higher error rates in comparison to sequences involving /l/ and /w/ in the responses of our French-speaking children.

Clinical Implications

When considering these data in view of previously published data on the acquisition of consonants in French, some recommendations for clinical practice can be made. First, and most importantly, cluster reduction is a natural process in speech but francophone children are expected to master consonant sequences at an early age, especially in word initial position. According to MacLeod et al. (2011), mastery of the /l/ clusters can be expected by age 36 months and the /w/ clusters by 42 months. Although the /s/ and /ʁ/ segments are relatively late developing in French, they are mastered by 48 months as are the /s/ and /ʁ/ clusters. Therefore, children such as those described in this report, who continue to misarticulate these clusters past the age of 48 months, are most likely in need of speech therapy and targeting these clusters with the expectation of phonological and phonetic mastery is an appropriate therapeutic goal. Even in the case of simplification errors, there is no need to wait until age 7 to 9 before addressing these errors as one might when treating English-speaking children who produce /s/ and /ɹ/ clusters with phonetically incorrect segments.

Second, the error pattern involving spreading of dorsal within /ʁ/ and /w/ clusters appears to be typical in French-speaking children. This pattern of spreading results in errors that might be called "backing", i.e., 'train'→ [kʁɛ̃] and 'doigt' →[gwa], which, in English, would be considered to be highly atypical and might trigger the selection of approaches to speech therapy that are directed at motor or phonological planning rather than phonological knowledge. However, in these francophone children this common error arises from spreading of a phonological feature between segments rather than an issue with lingual control specifically.

Third, French prosody should be taken into account when targeting clusters in therapy (for overview, see Demuth & Johnson, 2003). Wauquier and Yamaguchi (in press) present evidence that French prosody is organized at the level of the phrase, with primary stress falling on the last syllable and a counter stress falling on the first syllable of the phrase; these two syllables form the pillars of an 'accentual arc' that encloses varying numbers of unstressed syllables. When conducting speech therapy in French, it may be most efficient to focus practice on the word initial position of two syllable words (i.e., syllables with less stress), practicing those words in a phrase composed at least of a determiner plus the target word. If the child can learn to produce the target phoneme in this context, it is expected that spontaneous generalization to easier contexts (single syllable words and the stressed final syllable of multisyllable words) will occur. For example, practice of the [fʁ] cluster in phrases such as 'une framboise' (in which the cluster occurs in the unstressed syllable) may promote generalization to the stressed syllable in phrases such as 'des fraises' and 'l'Afrique'. If the child is struggling to master the target, systematic practice in all of these prosodic contexts will be necessary. Further to the issue of prosody, it is advisable to avoid modeling the target forms with epenthesis as a strategy for promoting inclusion of both segments (e.g., 'une fraise' → [yn fəʁɛz] or 'traineau'→ [œ̃ təʁɛ̃no]. This strategy is common in English speech therapy sessions but epenthesis appears to occur rarely in French-speaking children and violates French prosody.

Limitations

Before concluding, we point out again that these data were collected in the context of a randomized controlled trial of interventions for the remediation of speech delay in francophone children. The speech sampling procedure was not specifically designed to investigate consonant sequence acquisition and the data reported here involve target words taken from a larger diagnostic test protocol. Therefore, the interpretation of the findings is subject to some cautions stemming from the weaknesses in the research design. First, a word list that sampled the three types of sequence (true cluster, adjunct /s/, and rising diphthong) with greater balance and depth is obviously required in follow-up studies. Second, a broader age range would be desirable in future studies so that epenthesis could be studied among younger children with speech delay and the resolution of these error patterns among older children might be described. Third, the differences observed between the monolingual and multilingual subsamples in this report require further investigation. In this study, the multilingual sample was relatively small and the finding of greater accuracy among these children may well have been due to sampling error. In another study involving normally developing kindergarten and grade one children we found no statistically significant differences in articulation accuracy between children who were monolingual speakers of French compared to those who spoke other languages at home (Rvachew et al., 2013). However, no clear conclusions can be drawn about the development of speech articulation accuracy among children with speech delay who have varying language exposures without considerably more study of this population.

In conclusion, our description of consonant sequence errors by francophone children reveals similarities and differences in comparison to English-speaking children that must be taken into account when planning phonology intervention for French-speaking children with DPD. The data presented in this paper provide a picture of error patterns that are typical among francophone children with DPD that will help when deciding if a given child should be a high priority for intervention.

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Appendix A

Child	Clown	Glissade	Brun	Train	Traineau	Crayon	Graffigner	Framboise	Spectacle	Fleur	Doigt	Cuisine
1101	klun	liad	joẽ	jɛ	jɛno	ɛjɔ	aiɲe	ɑ̃bwaz	pɛtak	loeʁ	wa	ɥin
1102	kun	gisad	bʁoẽ	kɛ	kɛno	kɛjɔ	gaifiɲe	fɑ̃baz	pɛktak	poeʁ	da	kizin
1103	klun	glisad	bʁoẽ	tʁɛ	tʁɛno	kʁɛjɔ	gʁafiɲe	fʁɑ̃bwaz	pɛstak	floew	dwa	kɥizin
1104	klun	gis̪ad	bʁoẽ	kʁɛ	tʁɛno	kʁɛjɔ	gafine	fɑ̃bwaz	pɛktak	fwoeʁ̪	dwa	kɥiz̪in
1105	klun	glisad	bʁoẽ	tʁɛ	twɛno	kʁɛjɔ	gʁafiɲe	fʁɑ̃bʁaz	pɛtak	fwoew	dwa	kɥizin
1106	lun	gisa	boẽ	kwɛ	kʁɛno	twɛjɔ	gasiɲe	fɑ̃bwaz	pɛstak	fwoeʁ	da	tizin
1107	kun	gisad	bʁoẽ	kʁɛ	kɛno	kʁajɔ	gʁafine	bɑ̃bwaz	pɛktak	foeʁ	dwa	kɥizin
1108	k̪lun	isad	bʁoẽ	tʁɛ	kʁɛno	ɛjɔ	ʁate	babwaz	ɛtak	fwa	bwa	bɥizin
1109	kun	gisad	boẽ	tɛ	tɛno	kʁɛjɔ	gʁafiɲe	tɑ̃bwaz	pɛtak	foeʁ	da	kizin
1110	kun	gwis̪ad	boẽ	tsɛ	tɛno	kʁɛjɔ	gafine	fɑ̃baz	pɛstak	faw	ga	kasin
1111	klun	glisad	bʁoẽ	tʁɛ	teno	kʁɛjɔ	gafiɲe	fʁɑ̃bwoiz	spɛstak	floeʁ	dwa	kɥizin
1112	klun	gwita	bwə	k̪lɛ	kjɛno	kɔglɔ	gjafi	fʁɑ̃bwa	pita	s̪lɑ	ja	tizin
1113	klun	glisad	bʁoẽ	kʁɛ	kʁɛno	kʁɛjɔ	gʁafiɲe	fʁɑ̃bwaz	pɛstak	floeʁ	dwa	kɥizin
2102	klun	glisad	bʁoẽ	ʁɛ̃	tɛno	ʁɛjɔ̃	gʁafiɲe	fʁɑ̃bwaz	pɛstak	floeʁ	dwa	kɥiz̪in
2103	klun	glisad	bʁoẽ	tʁɛ̃	tʁɛno	kʁɛjɔ̃	gʁafiɲe	fʁabwaz	pɛstak	floeʁ	dwa	kɥizin
2104	klun	is̪lad	bʁoẽ	tʁa	nɛno	najɔ̃	laɲe	nɑ̃bwa	nɛta	loe	dwa	nani
2105	klun	glisad	bʁoẽ	tʁɛ̃	tʁɛno	tʁɛjɔ̃	gefine	fʁɛbwaz	pɛstak	loeʁ	gwa	kwizin
2106	klun	glisad	bʁoẽ	kʁɛ̃	kʁɛno	kʁɛjɔ̃	gʁafiɲe	ʁɑ̃bbwaz	pɛtak	floeʁ	dwa	kyzin
2107	klun	glisad	bʁoẽ	tʁɛ̃	tʁɛ	kʁɛjɔ̃	gʁafine	fʁɑ̃bwaz	pɛstak	floeʁ	dwa	kɥizin
2108	kun	gjisad	bjoẽ	kje	kjɛno	kjɛjɔ̃	gjafiɲe	kwɑ̃bjaz	pɛtak	fjoe	gwa	kɥizin
2109	tun	disa	boẽ	tɛ̃	teno	kɛjɔ̃	gʁafini	fɑ̃bʁaz	petak	floew	wa	tizin
2110	klun	glizɑ̃d	bʁoẽ	tʁɛ̃	klɛno	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bʁaz	spɛktakl	floeʁ	gwa	kwizin
2111	klun	glisad	bʁoẽ	kʁɛ̃	tʁɛno	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bwaz	petak	floew	dwa	kɥizin
3101	klun	glisad	bœ̃	kʁɛ̃	tɛno	kɛjɔ̃	gʁafiɲe	fɑ̃waz	pɛtak	flœʁ	dwa	kwizin
3102	klun	gliʃad	bʁœ̃	ʁɛ̃	kʁɛno	kɛjɔ̃	gʁafiɲe	fʁɑ̃bʁaʒ	pɛstak	flœʁ	dwa	kɥizin
3103	klun	glisad	boẽ	tɛ̃	kɛno	kɛjɔ̃	gafiɲe	fɑ̃bwaz	pɛktak	floeʁ	gwa	kɥizid
3104	ku	gwisa	bwœ̃	fwɛ̃	tɛno	kɛjɔ̃	gamize	sɑ̃bwa	spɛta	fwoe	bwa	kizi
3105	kənu	gisa	bœ̃	kjɛ̃	tɛno	tejɔ̃	gatine	sɑ̃bwaz	pɛstak	fjœ	dwa	kizin

Table continues on the next page

Appendix A *(contined)*

Child	Clown	Glissade	Brun	Train	Traineau	Crayon	Graffigner	Framboise	Spectacle	Fleur	Doigt	Cuisine
3106	klun	glisad	bʁœ̃	tʁɛ̃	tʁɛno	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bwaz	fɛstak	flœʁ	dwa	kɥizin
3107	tun	glisa	ʁœ̃	ʁɛ̃	ʁɛno	kɛjɔ̃	egatine	ʁɑ̃bwa	pɛtak	fœʁ	wa	tizin
3108	kʁun	gis̯ad	bœ̃	kʁɛ̃	tɛno	kɛjɔ̃	mafiɲe	fɑ̃bwaz	petak	fɛʁ	dwa	kɥiz̯in
3109	klun	gwisad	kʁœ̃	kʁɛ̃	kʁɛno	kʁɛjɔ̃	gʁafiɲe	kʁɑ̃bwaz	pɛstak	flœʁ	dwa	kizin
3110	klun	glisad	bʁoẽ	kʁɛ̃	kʁɛno	kʁɛ̃jɔ̃	gʁafiɲe	fɑ̃bwaz	pɛstak	floeʁ	dwa	kɥizin
3111	klun	glisad	bwœ̃	kʁɛ̃	tiʁo	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bwaz	pɛstak	flœʁ	dwa	kɥizin
3112	kun	glistad	bʁoẽ	kɛ̃	kʁeno	kʁɛjɔ̃	gʁafiɲe	kʁɑ̃bwatz	pɛstak	floeʁ	dwa	kyzin
3113	klun	glisad	bloẽ	tʁɛ̃	tʁɛno	kɛjɔ̃	gafiɲe	gɑ̃bwaz	pɛtak	floeʁ	dwa	kɥizin
3114	kun	glisad	bʁoẽ	tʁɛ̃	tʁɛno	tɛjɔ̃	gafiɲe	kʁɑ̃bwaz	pɛstak	koeʁ	dwa	kɥizi
4101	kʁun	g̪lisad	bjoẽ	kwɛ̃	kwɛno	kʁɛjɔ̃	ʁawiɲe	kʁɑ̃bwaz	pɛtak	floew	bwa	kɥizin
4102	tlun	gjisad	bwoẽ	tʁɛ̃	tɛno	kɛjɔ̃	ganine	fɑ̃baz	pɛstak	floeʁ	dwa	kɥizin
4103	klun	glisad	bʁoẽ	tʁɛ̃	tʁɛno	tʁɛjɔ̃	gʁafiɲe	kʁɑ̃bwaz	pistak	floeʁ	dwa	kɥizin
4104	klun	gwisad	bʁoẽ	tʁɛ̃	kʁɛno	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bʁaz	pɛstak	floeʁ	dwa	kɥiz̯in
4105	klun	glisad	bʁoẽ	tʁɛ̃	tʁɛno	kwɛjɔ̃	faneɲe	fʁɑ̃bwaz	pɛtak	floeʁ	dwa	kwizin
4106	klun	glisad	bʁoẽ	ʁɛ̃	tʁɛno	kʁɛjɔ̃	gwafiɲe	fʁɑ̃baz	pɛtak	floeʁ	fwa	kwisin
4108	klun	glisaʁd	bʁoẽ	kʁɛ̃	kʁɛ̃no	kʁɛjɔ̃	gʁatiɲe	kʁɑ̃bwaz	pɛstak	floeʁ	dwa	kɥizin
5101	tu	gis̯ad	bu	ti	tɛno	tɛjo	gafine	fɑbaz	pitat	fa	pa	pijin
5102	klun	glisad	bʁoẽ	tʁɛ	tʁɛno	kʁɛjɔ̃	gʁafiɲe	fɑ̃bwaz	pɛtak	floeʁ	dwa	kyzin
5103	klun	glisad	boẽ	tʁɛ̃	tɛjo	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bwaz	pɛstak	floeʁ	bʁa	kɥizin
5104	kʁun	lisa	ʁœ̃	ʁɛ̃	ʁɛno	kɛjɲ	glafiɲe	ɑ̃bwa	pɛkak	ʃœʁ	dɑ̃	lizin
5105	klun	gisad	bʁoẽ	tʁɛ̃	kʁɛno	kɛjɔ̃	gʁafiɲe	kʁɑ̃bwaz	pɛskak	floeʁ	dwa	kɥizin
5106	klun	glis̯ad	bʁoẽ	kʁɛ̃	kʁɛno	kʁɛjɔ̃	gʁafiɲe	fʁɑ̃bwaz	pɛtak	s̯loeʁ	da	kizin

Note: ***Bolded participant numbers*** *denote children who were reportedly exposed to a language other than French. Exposures ranged from 1% to 25% of the time at home, with 4 children receiving 5% or less second language exposure, 4 children receiving 20% or more second language exposure and the remainder being in between these extremes. Second languages were English, Spanish, Arabic, Algerian, Cambodian, and Lingala.*