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ARTICLE

Revisiting the Acquisition of Onset Complexity: Affrication in Québec French

Natália Brambatti GUZZO*

Department of Linguistics, McGill University
*Corresponding author: Department of Linguistics McGill University 1085 Dr Penfield Montréal, QC Canada H3A 1A7 E-mail: nataliaguzzo@me.com

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Abstract

I investigate the acquisition of affrication in Québec French (QF), where affricates are in complementary distribution with coronal stops, being realized before high front vowels and glides. Previous research on other languages shows that affricates are acquired before branching onsets, which supports the idea that complexity at the level of the segment is acquired before complexity at the level of the syllable (Lleó & Prinz, 1997). In contrast, I hypothesize that affricates are acquired after branching onsets in QF, as learners are required to understand the constraints on their distribution. I examine longitudinal data from two QF-speaking children for whom the acquisition of branching onsets has been previously analyzed (Rose, 2000). Results show that affricates are indeed acquired after branching onsets, consistent with the hypothesis. Overapplication errors indicate that children make generalizations about the phonological constraints on affrication from an early age, which is expected for the acquisition of rules.

Keywords: affrication; branching onsets; syllable structure; Québec French

Introduction

Previous research on the acquisition of syllable structure has shown that affricates (e.g., /t͡s,d͡z,t͡ʃ,d͡ʒ/) are acquired before branching onsets (e.g., /pr,pl,kr,kl/). This is the case for languages such as English (Gierut & Champion, 1999, 2001; Gierut & O'Connor, 2002), German and Spanish (Lleó & Prinz, 1997). Affricates are contour segments (i.e., segments with a sequence of different features) that occupy a single timing slot in the syllable structure (Clements & Hume, 1995). They thus differ from branching onsets, which are formed by multiple segments, each of which occupies its own timing slot in the syllable (Broselow, 1995). This order of acquisition (affricates > branching onsets) supports the idea that syllable structure expands hierarchically, with complexity emerging earlier at lower levels (Lleó & Prinz, 1996, 1997).

In the languages in which support for this proposal has been found, affricates are contrastive. In other words, affricates are separate phonemes (compare *tip*, *ship*, *chip*

in English), not allophones of other phonemes. However, in some languages, affrication is not phonemic, but is instead realized in specific phonological contexts. The question that arises is whether languages where affrication is not contrastive exhibit the same acquisition path, or whether the phonological constraints underlying non-contrastive affrication are more onerous for children than those underlying branching onsets.

To answer this question, this paper focuses on the acquisition of affricates [t͡s,d͡z] in Québec French (QF), where affricates are in complementary distribution with [t,d]. In QF, [t͡s,d͡z] are realized before high front vowels /i,y/ (e.g., [t͡siʁe] *tirer* 'to pull', [tɔʁt͡sy] *tortue* 'turtle'), their lax allophones [ɪ,ʏ] (realized in closed syllables; e.g., [t͡sɪp] *type* 'type', [t͡sʏk] *tuque* 'winter cap'; Walker, 1984), and palatal glides [j,ɥ] (e.g., [t͡sjɛ̃] *tiens* 'hold.IMP', [kɔ̃d͡zɥɪʁ] *conduire* 'to drive'); before all other vowels, [t,d] are found (Walker, 1984; Dumas, 1987). Affrication in QF is thus a variable phenomenon in that it involves the mapping of an underlying representation to two possible surface forms. Additionally, while affrication is categorical word-internally, it does not apply categorically across words.

There are two possible outcomes for the acquisition of affrication in a language such as QF. On the one hand, it is possible that QF-speaking children acquire affricates BEFORE branching onsets, similarly to what has been observed for English, Spanish and German. As the gestures for the stop and release parts of QF affricates share the same place of articulation, and affrication is triggered by a high front vocoid, children might acquire the process once they are able to produce coarticulation (either at the target segment or between the target segment and the following vocoid). On the other hand, it is possible that, unlike in English, Spanish and German, affricates are acquired AFTER branching onsets in QF. This is because the acquisition of affrication in QF requires children to understand the constraints that regulate the distribution of affricates in their phonological system. Thus, in addition to understanding that affricates are not contrastive in the language, QF-speaking children also need to understand which phonemes affricates are allophones of (e.g., coronal stops, not coronal fricatives), as well as which following vocoids license affrication (e.g., high front, not high back).

These two possibilities are fundamentally different. The second possibility (branching onsets > affrication) is consistent with the observation that a rule must be acquired for affrication to be accurately produced in the language, and it is thus independent of the development of specific motor skills. In this case, productions should be increasingly target-like, and children may be sensitive to different aspects of the process (e.g., children might exhibit different accuracy rates depending on the underlying consonant). Furthermore, as children sort out the constraints on affrication, they may overapply the process, similarly to what has been observed for the acquisition of other phonological rules (e.g., Spanish-speaking children often overgeneralize the predominant trochaic pattern to words with final stress; Lleó & Arias, 2007). I hypothesize that the acquisition of affrication in QF follows from the second possibility.

Research on the acquisition of (variable) phonological rules has shown that children's productions are overall similar to adults', which indicates that children are both sensitive to variation in the input and able to acquire the constraints that govern variable phenomena (e.g., Labov, 1989; Guy & Boyd, 1990; Roberts, 1994, 1997; Miller, 2013). However, research on the acquisition of variation has focused mostly on phenomena that apply probabilistically. Research on the acquisition of complementary distribution, on the other hand, has been scarce. While it has been shown that infants are sensitive to distributional information in the input (see e.g.,

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Jusczyk, 1997), the acquisition of complementary distribution involving allophones that not only differ in manner of articulation (stops and affricates, in this case), but also apply categorically in specific phonological contexts, has been largely overlooked in the literature.

In this paper, I examine longitudinal data from two QF-speaking children, Clara and Théo, to investigate when affrication is acquired relative to branching onsets. Both children were recorded from the period when they were producing their first words; they were recorded regularly for a relatively long period of time (19 months for Clara, 26 months for Théo). Their productions have been the subject of several phonological analyses (Rose, 2000, 2002, 2003; Goad & Buckley, 2006), which provide an extensive picture of their phonological development, allowing the present analysis to place the acquisition of affrication in their developmental timeline. Before turning to the data under analysis, I discuss affrication in QF, as well as the acquisition of affrication, onset structure in QF, and variable phenomena.

Affrication in Québec French

QF is different from other varieties of French (such as Standard Parisian French) in that it exhibits affrication (referred to as assibilation in some studies; Walker, 1984; Côté, 2014). Affrication seems to have emerged in Montréal (Friesner, 2010), but it is currently observed in all parts of Québec. The process is not socially stigmatized in Québec, having become prevalent in mainstream Québec media over the past 40 years (Chalier, 2019).

Affrication in QF refers to coronal stops /t,d/ being realized as [t͡s,d͡z] when followed by a high front vowel or glide. Both rounded [y] and unrounded [i], as well as both rounded and unrounded glides [ɥ] and [j], trigger the process. In addition, affrication is prosodically conditioned: it applies categorically within the phonological word, across the elements of a compound and in clitics such as *tu* [t͡sy] 'you' (Walker, 1984; Côté, 2014). There is some disagreement as to which extent affrication applies in other contexts. Walker (1984) argues that affrication is variable in verb+enclitic structures and in proclitic+word structures, but blocked across phonological words. Based on data from several regions of Québec, Côté (2014) argues that affrication is variable in proclitic+word structures and across phonological words (with or without liaison), and categorical in verb+enclitic structures. Table 1 summarizes the contexts for categorical and variable affrication in QF, following Côté (2014).

As detailed below, the children under analysis produced only a handful of proclitic +word structures (5) and phrases (6 and 7 in Table 1) that offer context for affrication. No compounds (3) and verb+enclitic structures (4) were produced. For this reason, this study focuses on affrication word-internally and in clitics (1 and 2 in Table 1), where affrication is categorical. Although children are exposed to forms where affrication is variable, which might impact their understanding of the process, variation is predictable based on prosodic context. Children must then learn that affricates are in complementary distribution with coronal stops (instead of coronal fricatives, for example), that affrication applies whenever the following vowel is high AND front (instead of high back, such as [u], or upper-mid front, such as [e]), and that, word-internally and in clitics, affrication applies categorically. Failing to understand these constraints may lead to overapplication of the process. Table 2 illustrates potential cases of overapplication of affrication in child speech.

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Table 1. Contexts for categorical and variable affrication of /t,d/ in Québec French

	Structure	Example	Orthography/Translation	Status
1	Word-internal	t͡si.ʁe tɔʁ.t͡sy	*tirer* 'to pull' *tortue* 'turtle'	Categorical
2	Clitics	t͡sy d͡zy	*tu* 'you' *du* 'of-the'	Categorical
3	Compounds	sɛ.t͡sɪl	*Sept-Îles* (place name)	Categorical
4	Verb + enclitic	bwa.t͡sɪl	*boit-il* 'does he drink'	Categorical
5	Proclitic + word	d͡zi.maʒ~di.maʒ	*d'image* 'of pictures'	Variable
6	Across phonological words without liaison	sɛ.t͡si.de~sɛ.ti.de	*sept idées* 'seven ideas'	Variable
7	Across phonological words with liaison	se.t͡si.si~se.ti.si	*c'est ici* 'it's here'	Variable

Regarding Table 2, overapplication of affrication seems more likely in contexts 1, 3 and 4: namely, when the string has a coronal fricative in target position (/s,z,ʃ,ʒ/), or a high back vowel (/u/) or upper-mid front vowel (/e/) in trigger position. In the case of 1, this is because the release portion of QF affricates corresponds to a coronal fricative, so children might assume that [t͡s,d͡z] are in complementary distribution with the coronal fricatives found in QF, and overapply affrication with an underlying coronal fricative.

In the case of 3, children might assume that affrication applies whenever the target consonant is followed by a high vowel, regardless of its specification for [back]. This pattern would be consistent with what is observed in some natural languages where affrication applies before high vowels. One example is Japanese, where alveolar stops are realized as affricates before high vowels (/ti/ → [t͡ʃi], /tu/ → [t͡su], the difference in vowel quality in the latter pair is not a result of affrication; Ito & Mester, 2015).

In the case of 4, children might assume that affrication is also triggered by a following upper-mid front vowel, as the upper-mid front vowels /e,ø/ and the high front vowels /i,y/ (especially when they are produced as lax) are articulated relatively close to each other in QF. Such a pattern of affrication is also found in some natural languages, such as Polish, where coronal consonants are palatalized (to affricates) before nominal suffixes with a high or mid front vowel (Rubach, 2011).[1] Finally, affrication in cases 2 and 5 in Table 2 seems less likely, as it involves segments that are featurally more distant from the target/trigger segments than those in 1, 3 and 4. I return to the issue of overapplication in subsequent sections. I turn now to discuss previous studies on the acquisition of affricates and branching onsets.

Acquisition of affrication versus acquisition of branching onsets

Studies on phonological development have consistently shown that affricates (and fricatives) are acquired after stops. This has been observed for languages such as English (Stoel-Gammon, 1985), Cantonese (So & Dodd, 1995), and Korean (Kim &

[1]In Polish, the quality of the mid front vowel is closer to [ɛ] than [e], but [ɛ] and [e] are not contrastive (Gussmann, 2007), as they are in French.

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Table 2. Possible contexts for overapplication of affrication

	Target segment	Example
1	Affrication with an underlying coronal fricative	*it͡si (vs. isi *ici* 'here') *t͡sjɛ̃ (vs. ʃjɛ̃ *chien* 'dog')
2	Affrication with an underlying non-coronal stop	*t͡sje (vs. pje *pied* 'foot') *t͡sɥɪs (vs. kɥɪs *cuisse* 'thigh')
	Trigger segment	**Example**
3	Affrication with an underlying high back vowel	*t͡su (vs. tu *tout* 'all')
4	Affrication with an underlying upper-mid front vowel	*d͡ze (vs. de *des* 'of-the.PL')
5	Affrication with other non-trigger vocoids	*d͡zod͡zo (vs. dodo *dodo* 'sleep')

Stoel-Gammon, 2011), with fricatives and affricates being acquired around the same time. Unlike English, neither Cantonese nor Korean have branching onsets, which renders direct comparisons with QF impracticable. Nevertheless, data from these languages are overall consistent with the proposal that less complex structures among non-continuants are acquired earlier than more complex structures such as contour segments.

As previously mentioned, affricates differ from branching onsets in that they occupy only one timing slot in the skeletal tier of the syllable. Branching onsets, on the other hand, occupy multiple timing slots (one per segment). Affricates also differ from singleton segments in that their timing slot in the skeletal tier branches into two, to accommodate the features that correspond to the beginning of the segment and its release (see Clements & Hume, 1995; Lleó & Prinz, 1997; Gierut & O'Connor, 2002).[2] Figure 1 illustrates the representational differences between singleton onset segments, affricates and branching onsets.

The representations in Figure 1 suggest that, if structural complexity plays a role in language acquisition, then segments that have no structural complexity should be acquired before segments that are structurally complex, and structurally complex segments should be acquired before structurally complex onsets (a > b > c in Fig. 1). This order of acquisition follows from the proposal that acquisition is hierarchical, in that lower level structures (such as contour segments) are acquired before higher level structures (such as branching onsets) (Lleó & Prinz, 1996, 1997).

Observations of acquisition paths in languages that exhibit both affricates and branching onsets have supported this proposal. Lleó and Prinz (1997) examined longitudinal data from five children acquiring German and four children acquiring Spanish. In both languages, affricates have phonemic status, but while Spanish has only one affricate (/t͡ʃ/), German has four (/t͡s,t͡ʃ,d͡ʒ,pf/). Tokens with affricates and clusters (in the syllable onset for Spanish, and either in the onset or in the coda for German) were extracted from recordings of children's productions from age 1;5 to age 2;2, with the age range split into three periods for the analysis. Lleó and Prinz (1997) found that, in onset position, both Spanish-speaking and German-speaking

[2]LaCharité (1993) proposes a different account for the representation of affrication, according to which affricates are strident stops (i.e., stops with the [+strident] feature). In this analysis, however, affricates are still complex segments, since they bear features of both stops and sibilants.

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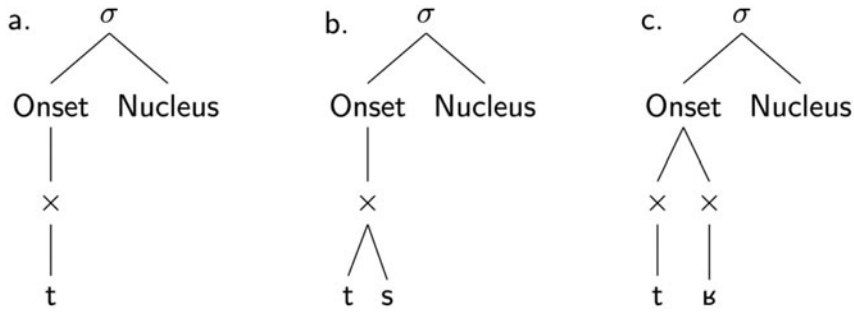

Figure 1. Syllable (σ) onsets by complexity: singleton onsets (a), contour segments/affricates (b), and branching onsets (c). × indicates the skeletal tier.

children were more accurate in the production of affricates than in the production of branching onsets, in all three periods. For both languages, no accurate production of branching onsets was observed for the first period (1;5–1;7). At the intermediate period (1;8–1;10), Spanish children still did not exhibit any accurate production of branching onsets, whereas German children produced approximately 10% of branching onsets accurately. At the final period under examination, German children's accurate production of branching onsets increased to approximately 30%, while Spanish children's accurate production was at approximately 10%. It should be noted that neither German nor Spanish children seemed to have mastered affrication during the periods under examination. German children produced affricates accurately about 45% of the time in all three periods, while Spanish children started out with about 20% of accurate affricates and had approximately 30% of target-like productions at the final period. Although the data do not reveal at which point affricates and branching onsets are in effect acquired by these children, they support the idea that affricates emerge earlier than branching onsets, in line with the proposal that complexity at the level of the segment is acquired earlier than complexity at the level of the syllable (Lleó & Prinz, 1996, 1997).

The acquisition of affricates and branching onsets in English seems to follow a similar pattern. Gierut and Champion (1999) analyzed longitudinal data from a child with phonological delay who was in treatment for the production of three-element clusters. They found that, during treatment, some new untreated phonemes were added to the child's inventory, among which were affricates /t͡ʃ,d͡ʒ/. The child produced such affricates accurately in target contexts, but also overgeneralized them to branching onsets (e.g., [d͡ʒoʊ] for *grow*, [t͡ʃoʊn] for *throne*). Gierut and Champion (1999) argue that overgeneralization of affrication, as well as the observation that affricates were the first sounds to emerge among the newly learned sounds, indicates that the emergence of affrication precedes the emergence of branching onsets. In a later study with similar methodology based on data from eight children with phonological delay, Gierut and Champion (2001) obtained comparable results, with children adding affricates to their inventories before the emergence of complex onsets. In a corpus analysis of productions from 110 English-speaking children with phonological delays, Gierut and O'Connor (2002) showed that 27 children employed affricates but not branching onsets, while only seven used clusters but not affricates, which further suggests that complexity emerges first at lower structure.

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Following from these observations for affrication, one should expect that other complex segments are also acquired before branching onsets. This appears to be the case for labialized dorsal consonants [kʷ,gʷ] in (European) Portuguese. In words such as [kʷal] *qual* 'which' and [ˈgʷaɾdɐ] *guarda* 'guard', the labialized dorsal+vowel string does not alternate with hiatus, which is what is typically observed in glide+vowel sequences in Portuguese ([ˈtwaʎɐ]~[tuˈaʎɐ] *toalha* 'towel'). This has led to the proposal that labialized dorsals in Portuguese correspond to complex segments instead of branching onsets or underlying dorsal+vowel sequences (d'Andrade & Viana, 1993; Collischonn, 2010). In an investigation of the acquisition of onsets in European Portuguese, Freitas (2003) observed that labialized dorsals precede branching onsets.

These results, however, do not speak directly to the issue under examination in this paper. Even though QF affricates are contour segments, they do not have phonemic status, being instead in complementary distribution with coronal stops. In this case, it is possible that QF-speaking children will take longer to acquire affricates than branching onsets, since acquiring affrication implies understanding the phonological constraints that govern complementary distribution in the language. To my knowledge, no study has focused on the acquisition of affricates and branching onsets in QF as a way to determine whether affrication associated with complementary distribution emerges later than onset complexity. In the next section, I discuss previous findings on the acquisition of singleton and branching onsets in QF.

Acquisition of onsets in Québec French

Regarding the acquisition of both singleton and branching onsets, MacLeod, Sutton, Trudeau and Elin Thordardottir (2011) investigated the developmental path of QF-speaking children aged 20–53 months based on cross-sectional data from over 150 participants. Their focus was not on the acquisition of prosodic constituency, but rather the acquisition of individual segments or strings. Using a 75% criterion as an indication of ACQUISITION and a 90% criterion as an indication of MASTERY, MacLeod et al. (2011) found that singleton /t/ is mastered between 24 and 35 months (word-initially at 24–29 months, and word-medially at 30–35 months), while singleton /d/ is mastered between 20 and 35 months (word-initially at 20–23 months, and word-medially at 30–35 months). Dental fricatives emerge roughly at the same time periods: initial and medial /s/ is acquired at 20–23 months, while /z/ is mastered at 30–35 months.[3]

Regarding branching onsets, MacLeod et al. (2011) found that different onsets are acquired or mastered at different ages. For example, while /bl/ (e.g., [blø] *bleu* 'blue') is acquired at 30–35 months, /kʁ/ (e.g., [kχʊt] *croûte* 'crust') is acquired only at 42–47 months. However, MacLeod et al. (2011) coded a given production as accurate only if it was completely target-like. In other words, branching onsets that were produced with two elements but where one of them does not match the target consonant were coded as inaccuracies (e.g., [tχʊt] for [kχʊt]). The analysis does not specify which types of errors (e.g., substitution, deletion) were produced in branching onsets, which precludes any decisive conclusion about when onset complexity is

[3]There is no information about when /s/ is mastered (i.e., produced accurately more than 90% of the time) by QF-speaking children. Presumably, accuracy with /s/ still does not surpass 90% at 48–53 months (MacLeod et al., 2011).

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acquired. On the other hand, the authors classify most branching onsets as CUSTOMARY (produced accurately at least 50% of the time) at 30–35 months, and a few others (/bl,fl/) at 24–29 months. This suggests that onset complexity emerges in children's phonological systems between ages 2 and 3, even though the individual segments of branching onsets may not yet be produced in a target-like manner. The children's productions analyzed in MacLeod et al. (2011) were elicited based on a picture naming task. None of the target words offered context for affrication, so no comparisons between the acquisition of affricates and branching onsets in QF can be made based on these data.

Rose (2000) analyzed longitudinal data from two QF-speaking children (Clara and Théo; see the *Method* section) and concluded that, with regard to onset complexity, children acquire branching onsets in stressed syllables first. Even though the existence of word-level stress in QF is disputed (see e.g., Walker, 1984; Thibault & Ouellet, 1996), with stress in adult QF being required only at the right edge of the phonological phrase (PPh; see (1)), children acquiring QF tend to consistently produce stress word-finally (Rose, 2000; Goad & Buckley, 2006). Branching onsets are thus acquired in word-final syllables and stressed monosyllables first (2), and later in unstressed positions (3).

(1) Stress in adult QF:

[lə	jɔli	gaʁˈsɔ̃]$_{PPh}$
le	*joli*	*garçon*
the	pretty	boy

(2) Acquisition of branching onsets in stressed syllables:

Production	Target form	Child/Age	Word	Gloss
klɪs	glɪs	Clara/1;10.04	*glisse*	(s/he) slides
θəˈtχu:j	sitχʊj	Clara/1;10.04	*citrouille*	pumpkin
gʁo	gʁo	Théo/2;05.29	*gros*	big
klʊn	klʊn	Théo/2;06.12	*clown*	clown

(3) Acquisition of branching onsets in unstressed syllables:

Production	Target form	Child/Age	Word	Gloss
tχuˈve	tχuve	Clara/2;03.15	*trouvé*	found
plɑ̃ˈʃe	plɑ̃ʃe	Clara/2;05.25	*plancher*	floor
kχaˈve	tχuve	Théo/3;00.07	*trouvé*	found
pløˈʁe	plœʁe	Théo/3;05.06	*pleurer*	to cry

The criterion for accuracy count in Rose (2000) is different from the one used in MacLeod et al. (2011): in Rose (2000), all items that exhibit possible onset clusters in QF are classified as accurate productions, including cases where one of the segments in the cluster is not quite target-like (e.g., Théo's production of *trouvé* in (3)).

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Although not quite target-like at the segmental level, these productions provide evidence that the children have acquired onset complexity.

As Clara's and Théo's productions are also the object of the present study, the question that arises is whether they acquire affrication before branching onsets. Rose (2000) points out that many branching onsets produced by Théo exhibit dorsal assimilation (see *trouvé* in (3)), which could be interpreted as an indication that the child is not producing branching onsets at this point, but rather affricates, whose elements share the same place of articulation. Rose (2000) dismisses this possibility based on two observations: (a) some of the clusters that exhibit dorsal assimilation exhibit voicing mismatch underlyingly (e.g., /kʁ/), which is crosslinguistically not observed in affricates, and (b) Théo's affricates ([t͡s,d͡z]) emerge after such clusters. However, Rose (2000) does not elaborate on when affricates are in effect ACQUIRED by the child relative to branching onsets, and whether affricates precede or follow branching onsets for the other child included in the study.

As previously mentioned, this paper investigates whether affrication precedes branching onsets in a language where affricates are not contrastive. Before turning to the data under analysis, I briefly discuss previous research findings on the acquisition of variable phonological phenomena.

The acquisition of variation

Children are exposed to variable phenomena from the onset of language exposure, as variation is intrinsic to natural language. Phonological variation arises when a single underlying form may be realized in multiple ways. Surface forms may be in complementary distribution, or they may be realized probabilistically. In the former case, the realization of a given allophone is restricted to a specific phonological context. This is what is observed in QF, where affricates are realized before high front vowels and glides. As mentioned, affrication in QF also has a probabilistic component, as it applies variably in certain contexts, such as across words.

The literature on the acquisition of variation has focused mostly on phenomena whose application is probabilistic, rather than on phenomena that involve allophones in complementary distribution. For example, Roberts (1997) investigated -t/d deletion by English-speaking children between three and four years from Philadelphia, as well as by their caregivers.[4] -t/d deletion is the process where the second element of a word-final cluster (a coronal stop) is deleted; it can apply in monomorphemic words (*nest*), regularly inflected verbs (*talked*) and irregularly inflected verbs (*lost*). Importantly, deletion is not categorical for any of these morphological shapes or in any phonological context. Thus, children's exposure to this phenomenon contrasts with exposure to affrication in QF: while English-speaking children are exposed to variable evidence that final -t/d deletes, QF-speaking children are exposed to categorical evidence that affricates replace [t,d] before high front vowels word-internally.

Roberts (1997) shows that while children delete -t/d more frequently in monomorphemic words and irregular verbs, their caregivers delete it more frequently in monomorphemic words and less frequently in inflected forms (both regular and irregular). Two observations can be made about these results: (i) children seem to be

[4]This process is examined in other studies on language acquisition, such as Guy and Boyd (1990). However, these studies typically focus on the productions of older children (over five years old) and thus will not be reviewed here.

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on the path toward complete acquisition of the phenomenon, and (ii) the mismatch between children's and their caregivers' productions (for irregular forms) seems to result from children not yet having acquired the target-like representation for inflected forms.

The same children, however, mirror adult behavior with respect to another variable phenomenon that applies probabilistically: namely, -ing variation (ˈlɪvɪŋ∼ˈlɪvɪn for *living*), favoring it in verbs and complements over nouns and adjectives (Roberts, 1994). However, -ing variation is not morphologically conditioned in the same way as -t/d deletion, as -ing variation does not target the morpheme as a whole, unlike -t/d deletion. These results thus suggest that it is not variation *per se* that is onerous for children, but rather the extent to which variation is constrained by structure.

This idea is further supported by the results found in Miller (2013), which investigates variable /s/ lenition by Spanish-learning children (aged 2;04 to 5;09) and their caregivers in Chile. /s/ lenition corresponds to the aspiration or deletion of coda /s/ ([ˈlapih]∼[ˈlapi] for [ˈlapis] *lapiz* 'pencil'). Children overall mirror their caregivers' production patterns in that they both favor deletion word-finally (as opposed to word-medially). However, age plays a role in the acquisition of the phenomenon, as younger children exhibit higher rates of deletion than older children. As the study does not mention how accurate children are with other codas, it is unclear whether the highest rate of deletion for younger speakers is a direct result of them not yet having acquired codas. It appears that, once children have acquired the necessary syllable structure (i.e., coda), they are able to handle variation in a target-like manner.

Turning to complementary distribution, it has been shown that limited exposure is sufficient for infants to understand allophonic patterns in complementary distribution. White, Peperkamp, Kirk and Morgan (2008) conducted experiments where 8.5-month-old and 12-month-old infants acquiring English were exposed to patterns of either fricative or stop (de)voicing word-initially. Results indicate that both younger and older infants were able to internalize the alternations, although only 12-month-old infants seem to be able to discriminate alternating from non-alternating patterns in more specific testing conditions. Observations from additional studies further support the idea that infants are able to use allophonic variation related to segmental structure (e.g., Jusczyk & Aslin, 1995; Jusczyk, Hohne & Bauman, 1999; see also Jusczyk, 1997) or prosodic structure (e.g., Christophe, Dupoux, Bertoncini & Mehler, 1994) to identify word boundaries. These data indicate that children are sensitive to complementary distribution from a very early age, although they do not provide information about when children acquire it in production.

Children's accurate production of allophones in complementary distribution seems to depend on their acquiring the relevant structures that condition allophony. This appears to be the case for the acquisition of aspiration in English, where aspirated voiceless stops are in complementary distribution with unaspirated voiceless stops, being typically realized at the left edge of stressed syllables (e.g., [p^h]ea, [k^h]lean). In an analysis of the acquisition of stops by an English-speaking child (Amahl; Smith, 1973), Goad (2012) argues that aspiration is acquired once the child's grammar is able to project the relevant feature ([spread glottis], which accounts for the realization of the laryngeal gesture), at approximately 2;11. Before then, the child alternates aspirated and unaspirated voiceless stops word-initially at roughly the same rates (between 2;08 and 2;11), and, in earlier stages, the child produces mostly unaspirated stops. These results suggest that complementary distribution, like variable phenomena that apply probabilistically, is acquired at an early age. However, the

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acquisition of aspiration in English and the acquisition of affrication in QF are different in an important respect. While aspiration relies on the coordination of gestures of different natures (laryngeal and oral), affrication relies on the licensing of contour segments with two oral gestures. It is thus possible that children take longer to acquire complementary distribution when one of the allophones exhibits overlapping oral gestures.

In summary, previous studies suggest that children are able to acquire variable processes and are sensitive to complementary distribution. What remains to be investigated is how children fare in the acquisition of complementary distribution involving a contour segment relative to the acquisition of onset complexity. In the next section, the methodology for collecting and analyzing data, as well as the linguistic profile of the children under study, are discussed.

Method

Participants

Longitudinal data from two QF-speaking children, Clara and Théo, were analyzed. These data are part of the GoadRose corpus, which is publicly available on *PhonBank* (Rose & MacWhinney, 2014).[5] There are two main reasons to use data from this corpus: (i) the recordings cover a substantial period of time for the two children, which allows researchers to observe the emergence and acquisition of relevant structures, and (ii) the phonological development of Clara and Théo has been extensively examined (Rose, 2000, 2002, 2003; Goad & Buckley, 2006), which makes it possible to situate the present results for affrication in the children's developmental paths.

Both children were born in Québec and raised in monolingual QF-speaking households, Clara in Québec City, Théo in Montréal, although his family is from the Bas St-Laurent area of Québec (200 kilometers northeast of Québec City). Despite some dialectal differences between Québec City QF and Montréal QF, both varieties behave identically with respect to affrication (Friesner, 2010; Côté, 2014).

Clara and Théo were recorded approximately once every two weeks. The recordings took place in the children's homes, while they were playing with toys or looking at picture books. Clara was recorded for 34 sessions, between the ages of 1;00.28 and 2;07.19. Théo was recorded for 45 sessions, between the ages of 1;10.27 and 4;00.00. Rose (2000) indicates that the children's first sessions coincided with the time they started to produce their first words.

Clara's first three sessions and Théo's first four sessions did not contain any words with affrication (or overapplication of affrication) nor words that offered context for affrication. Thus, the present analysis starts with tokens from Clara's fourth session at 1;03.07, and Théo's fifth session at 2;00.21. A few early sessions did not contain any target items either: sessions at 1;03.08 and 1;04.16 for Clara, and the session at 2;02.15 for Théo.

In this analysis, the children's data will be divided into periods based on major milestones. Despite the difference in age of production of first words, Clara and Théo have similar developmental paths. For example, Rose (2000, 2003) report that Clara has acquired word-final codas at 1;07.06 (e.g., [pɔl] for [bɔl] *bol* 'bowl', [bʊs] for [bʏs] *bus* 'bus'), while Théo has acquired them at 2;04.06 (e.g., [pɔç] for [bʏs] *bus* 'bus', [vwɑʁ] *voir* 'to see'). With regard to branching onsets, Rose (2000, 2002) report their complete acquisition (i.e., in unstressed and stressed syllables) by Clara

[5]Available at https://phonbank.talkbank.org/browser/index.php?url=French/GoadRose/.

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at 1;09.29, and by Théo at 2;05.29. Although the criterion for acquisition is not specified in Rose (2000) (i.e., whether 75% or higher), later work reports that branching onsets in stressed position are realized with 100% accuracy by Clara between ages 1;09 and 2;03, and with 97.4% accuracy by Théo between ages 2;05 and 2;11 (Rose, 2002). In unstressed position, branching onsets are realized with 93% accuracy by Clara at age 2;03, and with 89% accuracy by Théo at age 3;00 (Rose, 2002). In Rose's analysis, productions with the target number of segments and legal consonantal strings are coded as target-like branching-onsets.

These patterns of acquisition suggest that, with regard to syllable structure, Théo's acquisition occurs roughly eight to nine months later than Clara's. The acquisition of word-internal codas (such as in [fɛʁme] *fermé* 'closed') is an exception to this time window: Clara's acquisition is at 2;03.19, while Théo's is at 3;07.06 (Rose, 2000, 2003). Nevertheless, Clara's and Théo's patterns for the acquisition of word-final codas and branching onsets allow us to split their recordings into specific age ranges in a principled way. Table 3 lists the age ranges considered in the present analysis by period.

Table 3. Classification of children's recordings into periods according to their acquisition of syllable structure complexity

	Clara	Théo	
Period	Age range	Age range	Structure acquired
1	1;03–1;07	2;00–2;04	Word-final codas
2	1;08–1;11	2;05–2;08	Branching onsets (stressed position)
3	2;00–2;03	2;09–3;00	Branching onsets (all positions) Word-internal codas (Clara)
4	2;04–2;07	3;01–3;04	
5		3;05–3;08	Word-internal codas (Théo)
6		3;09–4;00	

A few things should be noted about Table 3. First, periods 2 and 3 are crucial for the present analysis, as they correspond to the periods where branching onsets (in stressed position and in all positions within the word, respectively) are acquired by both children (Rose, 2000, 2002). Second, for the sake of consistency, the periods in Table 3 correspond to intervals of four months (except for the first period, which comprises five months), even though this division results in two periods where no particular structure is acquired (periods 4 and 6). Another consequence of this is that Théo's developmental path is split into more periods than Clara's, as Théo was recorded for a longer period of time. Third, while there are recordings for Théo for all the months included in Table 3, there are no recordings for Clara at 1;08, 1;11 and 2;04. These months are listed in Clara's age ranges in Table 3 so that the two children match in terms of number of months covered by each period.

Data collection and coding

The target items were extracted from *PhonBank*, based on the orthographic and phonetic transcriptions available. All items that contained a context for affrication in

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the target form (i.e., /t,d/ followed by /i,j,y,ɥ/) were included in the analysis ($n = 506$ including tokens with juncture and proclitic+word; see below). Additionally, cases where affrication was produced by the child but the target form did not contain any coronal stops were extracted (e.g., [t͡ʃjɛ̃] instead of [ʃjɛ̃] for *chien* 'dog'; $n = 72$). The remainder of tokens ($n = 2{,}412$) correspond to (a) items where /t,d/ are followed by another vowel (e.g., /de/ *des* 'of-the.PL'), to control for the possible overapplication of affrication with an underlying coronal stop (see Table 2), and (b) items where a non-coronal consonant was produced as coronal (e.g., [ʁəta] instead of [ʁəgaʁd] for *regarde* 'look.IMP'), since affrication could potentially be realized in this case. Items containing two coronal stops were coded twice, once per target syllable (e.g., *dodo* 'sleep'). A total of 2,990 tokens were extracted from *PhonBank*.

The phonetic transcription of the tokens was checked based on the audio files available on *PhonBank*. A random subset of items that had been transcribed as exhibiting affrication on *PhonBank* (approximately 10% of the total number of tokens) was examined in Praat, to ensure that they exhibited the phonetic signatures of affrication (burst followed by high frequency noise). A few tokens (approximately 5% of the total number of tokens) whose phonetic transcription did not seem to match the actual productions were further checked using Praat (Boersma & Weenink, 2019) to confirm that their coding was accurate. Tokens with a noisy background or where the child's production overlapped with an adult's production were discarded before inclusion.

Tokens were coded as exhibiting affrication regardless of the specific affricate produced by the child ([t͡s,d͡z,t͡ʃ,d͡ʒ,t͡ɕ,d͡ʑ]), as the objective of this study is to investigate when affrication is acquired relative to branching onsets, not when affrication is produced in a target-like manner. Tokens were thus coded based on (a) whether affrication was produced, (b) whether affrication was expected in the target form, (c) what the underlying vowel was, (d) what the underlying consonant was, (e) which vowel was produced, (f) which consonant was produced, and (g) whether the target syllable was stressed or unstressed. Contexts of juncture and proclitc+word (e.g., *un autre ici* [œ̃notisi] 'another one here', *d'image* 'of image') were also coded, but they were later removed from the analysis due to a negligible number of tokens (nine for juncture, two for proclitic+word).

Hypothesis and predictions

As mentioned earlier, it has been shown that, for languages where affricates are phonemic, affricates are acquired before branching onsets (e.g., Lleó & Prinz, 1997). It is unclear whether the same scenario applies in languages where affrication is not phonemic. As previously noted, two contrasting possibilities may account for the acquisition of affrication in QF: (i) affrication is acquired once children are able to produce coarticulation, in which case affrication precedes branching onsets, or (ii) the constraints on complementary distribution are onerous for children, in which case branching onsets precede affrication.

Target-likeness based on possibility (i) could be obtained in two ways: children acquire affrication (a) once they are able to produce segments involving two gestures, or (b) once they are able to coarticulate the target coronal segment with the following high front vocoid. View (a) stems from the idea that the production of affricates involves more complex articulatory efforts, and thus relies on the development of motor skills (see Hale & Reiss, 1998, for discussion). View (b) is based on the idea that the palatal place of the following vocoid triggers an

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assimilation process (e.g., Ohala, 1989; Corneau, 2000), so acquisition would take place once children are able to articulate this type of assimilation. Since coarticulation seems to be part of early child speech (see e.g., Nittrouer, Studdert-Kennedy & McGowan, 1989), any of these views predicts that QF-speaking children should be able to consistently produce affricates in the right context before they acquire branching onsets.

Instead, I hypothesize that possibility (ii) accounts for the acquisition of affrication in QF: to apply affrication in a target-like manner, children need to learn the constraints that govern the distribution of corresponding affricates and coronal stops in the language. Given the periods in Table 3 above, affrication should thus be acquired (based on the relatively conservative 75% criterion traditionally adopted by many acquisition studies; see previous sections) at or after period 4, once branching onsets have been acquired.

Children's production of affricates might be affected by the shape of the underlying forms, with certain segments or prosodic positions favoring target-like production. Specifically, affrication might be favorably conditioned by:

(i) underlying /t/ (instead of /d/). Crosslinguistically, /t/ and /d/ are acquired roughly at the same time (MacLeod et al., 2011; Stoel-Gammon, 1985). However, in English, the voiceless affricate (/t͡ʃ/) has been shown to be acquired earlier than its voiced counterpart (/d͡ʒ/; Dodd, Holm, Hua & Crosbie, 2003). The same pattern might be observed in QF.
(ii) underlying /i,j/ (instead of /y,ɥ/). Unrounded high front vowels seem to be acquired earlier than rounded high front vowels in languages that exhibit this contrast, such as Hungarian (Zajdó & Stoel-Gammon, 2003). Consequently, QF-speaking children may acquire affrication with unrounded vowels earlier than with rounded vowels, and produce singleton consonants (such as coronal stops) more frequently than affricates when the underlying vowel is rounded.
(iii) prominent positions, such as stressed syllables (relative to unstressed syllables), mirroring the acquisition path for branching onsets in QF (Rose, 2000).

The next section presents the results in light of the hypothesis and predictions.

Results

This section starts with the results for target-like application of affrication (i.e., when underlying /t,d/ are followed by a high front vowel/glide), which are first presented observationally and subsequently modeled statistically. The results concerning overapplication of affrication are discussed next.

Production of target-like affrication

Out of the 495 tokens where affrication was expected, it was produced in 361 of them (72.9%). Here, the productions under examination are those where /t,d/ are followed by a high front vocoid in the input, regardless of how the children actually produced them (e.g., [t͡sɪʁe], [tɪʁe], [t͡seʁe], [teʁe], etc, as attempts for the form *tirer* would all be included in the analysis).[6] The children performed considerably differently: Théo

[6]QF also have post-alveolar affricates [t͡ʃ, d͡ʒ], which are found mostly in borrowings and may appear before any vowel (e.g., *tchoutchou* [t͡ʃut͡ʃu], an onomatopoeic word for 'train', *jazz* [d͡ʒaz] 'jazz'). In Clara's and Théo's productions, only a handful of items with post-alveolar affricates were attempted. In Clara's data, only *sandwich* (1;10.09) and *apitchou* (onomatopoeia for 'sneeze'; 1;11.20) are observed,

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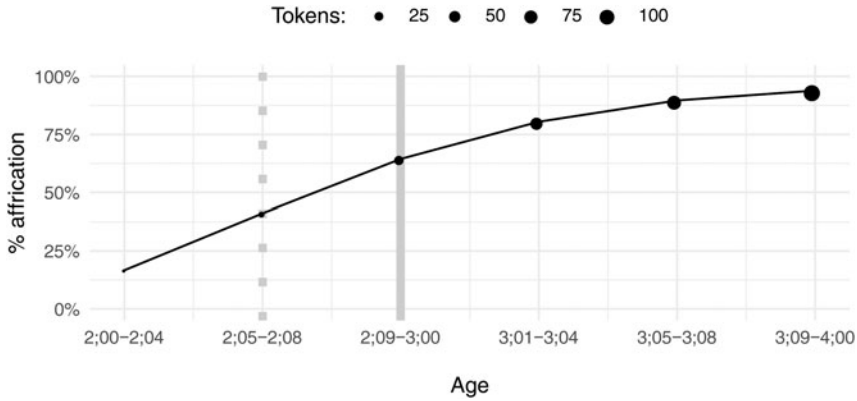

Figure 2. Production of target-like affrication by Théo at each time period.

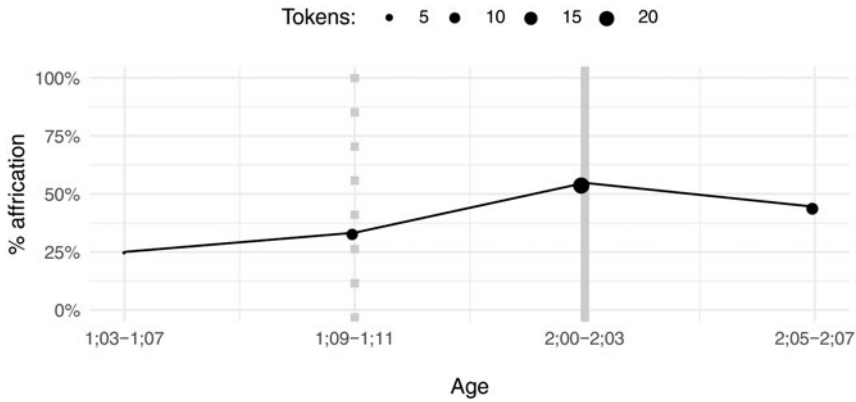

Figure 3. Production of target-like affrication by Clara at each time period.

affricated 81.8% of the time (312/381), while Clara affricated only 43% of the time (49/114). Figures 2 and 3 show Théo's and Clara's rates of affrication over the periods under analysis (the age ranges on the *x*-axis correspond to the periods in Table 3).

In Figures 2 and 3, the dotted vertical line and the solid vertical line indicate the periods where branching onsets are acquired in stressed position and in all positions, respectively (as per Rose, 2000, 2002). Following the 75% criterion for acquisition, neither of the children has acquired affrication by the time branching onsets in all

and both are produced with [ʃ]. In Théo's data, *tchoutchou* is observed ten times (from 2;02.02 to 3;05.26), and all productions have the target affricate from the third attempt at 2;08.02. He also produces *sandwich* twice (at 3;06.13 and 3;10.06), both of which with the target affricate. Since post-alveolar affricates are not allophonic in QF and their presence in children's productions is very limited, they are not included in this analysis. Théo also produces the word *pizza* with the target affricate ([pid͡za]) at 3;10.26. The analysis also excludes this item, given that affrication is not conditioned by a following high front vocoid in this case.

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positions have been acquired (period 3). Théo surpasses 75% in the following period: namely, period 4. On the other hand, Clara's period with the most accurate productions of affrication is period 3 (54.8%), and there is a slight decline in accuracy in period 4 (44.4%). These data are in line with the hypothesis that acquisition of affrication follows acquisition of branching onsets in a language where affricates are in complementary distribution with another allophone.

As mentioned above, factors associated with the shape of the underlying form may affect children's production of affrication. Table 4 summarizes the results for *underlying vowel*, *underlying consonant*, and *stress*.

Regarding *underlying vowel*, Théo's percentages of affrication for unrounded and rounded high front vowels are practically identical. Clara, however, produces affrication more frequently in the presence of an underlying unrounded high front vowel. It should be noted that Théo is overall more accurate than Clara across all periods in the production of high front rounded vowels when affrication is expected. While Théo exhibits very few substitutions (e.g., [i] for /y/), Clara frequently uses a different vowel in place of /y/, particularly in period 1. Nevertheless, there does not seem to be a specific pattern in her substitutions: for example, all [i,ə,e,ɛ,o] are used instead of [y] in period 1. Clara's rate of affrication for underlying /y/ remains low across the four periods, although she increasingly starts to produce a high front vowel in these contexts.

It should be noted that Clara produces more forms with underlying /y/ in period 4 than period 3 (15 vs. 10), which explains the decline in accuracy observed in Figure 3. In period 4, her productions of the high front rounded vowel are consistently more target-like, although she still fails to apply affrication with this trigger vowel most of the time. Clara's behavior is thus consistent with prediction (ii), which states that affrication should be acquired first with unrounded vowels, which have been shown to emerge earlier than rounded vowels (e.g., Zajdó & Stoel-Gammon, 2003).

Overall, both children produce affrication more frequently with underlying /t/, consistent with prediction (i) and with what has been observed for English, where voiceless affricates are acquired before voiced affricates (Dodd et al., 2003). Regarding *stress*, while Théo affricates both stressed and unstressed syllables at similar rates, Clara is more accurate with affrication in stressed syllables, consistent with prediction (iii).

Importantly, the data in Table 4 are not distributed equally throughout the age periods under analysis. For example, Théo does not produce any tokens with target /d/ at period 1, and only two tokens with /d/ at period 2. For this reason, while the results in Table 4 provide an overall description of children's acquisition of affrication, they do not inform us about their acquisition over time.

In contexts where affrication is expected, children's production of the trigger vowel is very accurate: high front vowels/glides were produced in 448 out of 495 tokens (90.5%; or 94/114 for Clara and 354/381 for Théo). The remainder of the productions displays vowels of different qualities. Regarding the target consonant, productions that do not contain an affricate exhibit a coronal stop (20.6% of the total tokens, or 102/495), a sibilant (2.8%, or 14/495), or a segment of a different quality (3.6%, or 18/495). Here, Clara and Théo also behave similarly in that, for both children, most inaccuracies involve the production of a coronal stop. However, most of Clara's productions of target items exhibit a dental stop in place of an affricate (54/114 *vs.* 49/114), while most of Théo's productions have an affricate (312/381 *vs.* 48/381 with a coronal stop).

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Table 4. Results for predictors related to the shape of the underlying form

	Théo		Clara	
Underlying Vowel	*Affricated/Total*	*%*	*Affricated/Total*	*%*
Unrounded (/i,j/)	172/210	81.9	33/62	53.2
Rounded (/y,ɥ/)	140/171	81.8	16/52	30.8
Underlying Consonant	*Affricated/Total*	*%*	*Affricated/Total*	*%*
Voiced (/d/)	67/87	77	10/36	27.8
Voiceless (/t/)	245/294	83.3	39/78	50.0
Stress	*Affricated/Total*	*%*	*Affricated/Total*	*%*
Stressed (*par**ti**, **tiens***)	217/264	82.1	40/83	48.1
Unstressed (***ti**rer*, ***du** jus*)	95/117	81.1	9/31	29

The children's data were modeled via logistic regressions (one per child, given the difference in number of periods between them) in R (R Core Team, 2020), with PRODUCTION OF AFFRICATION as the response variable. As the objective was to examine which structural factors condition the acquisition of affrication, only predictors related to the shape of the underlying form were included – namely, *underlying vowel*, *underlying consonant* and *stress*, as well as *age* (split into the periods listed in Table 3). Given the irregular distribution of some predictor levels in the data, stepwise selection was employed to determine which predictors should be included in the models based on AIC values (Akaike Information Criterion; Akaike, 1974).

For the logistic regression for Théo's data, all predictors were selected. Table 5 details the effect sizes (estimates) for this statistical model. Regarding *underlying consonant*, affrication is significantly less frequent with /d/. For underlying vowel, affrication is statistically more frequent with /y/. Given the proportions in Table 4, this effect may be due to the distribution of trigger vowels in the data: Théo produces words with /y/ such as *tortue* 'turtle', *statue* 'statue', and *perdu* 'lost' several times throughout the data, and most of them exhibit target-like affrication. Regarding *stress*, unstressed syllables overall disfavor affrication. This result may also stem from how stressed and unstressed target syllables are distributed in the data, as words with affrication in unstressed syllables become more frequent in Théo's productions from period 4. All age periods except for period 2 are significant predictors of affrication, relative to the intercept.[7]

As shown in Table 5, the effect size of *age* increases regularly from period 1 to period 6. This indicates that, from one period to the next, Théo produces target-like affrication at a higher rate. This result confirms the trend in Figure 2, which shows a relatively steady increase in affrication over time.

For the logistic regression for Clara's data, only *underlying vowel* was selected as a significant predictor. Clara produces affrication significantly less frequently with rounded high front vowels than with unrounded high front vowels ($\hat{\beta} = -0.94$, $p = 0.01$),

[7]As suggested by a reviewer, the statistical models for both children were alternatively run with *age* as a continuous variable, with similar results. Since modelling age by period allows us to draw comparisons with the observations for complex onsets in Rose (2000, 2002, 2003), this section discusses only the models where age is treated as a categorical variable.

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Table 5. Logistic regression (Théo). Estimates and associated 95% confidence intervals, standard errors, *z* values and *p* values. Estimates must be interpreted relative to the intercept (Period 1, /t/, /i/, stressed)

	Estimate ($\hat{\beta}$)	95% CI	Std. error	*z* value	*p* value
Intercept	−2.24	[−4.22, −0.78]	0.83	−2.67	0.007
Period 2	1.15	[−0.62, 3.28]	0.95	1.2	0.22
Period 3	2.91	[1.33, 4.95]	0.88	3.27	0.001
Period 4	4.04	[2.45, 6.09]	0.89	4.5	<0.0001
Period 5	4.93	[3.27, 7.04]	0.93	5.28	<0.0001
Period 6	5.78	[4.06, 7.95]	0.96	6.0	<0.0001
/d/	−1.42	[−2.25, −0.6]	0.41	−3.38	0.0007
/y/	1.22	[0.4, 2.12]	0.43	2.8	0.004
Unstressed	−1.58	[−2.5, −0.71]	0.45	−3.5	0.0004

consistent with the percentages in Table 4. *Age* was not selected, which is unsurprising given the trend in Figure 3.

These results thus indicate that both children acquire branching onsets BEFORE affrication, as hypothesized. While Théo acquires affrication at period 4, Clara's acquisition is not yet complete. The observation that the children's productions of affrication is constrained by different predictors (*underlying vowel* for Clara; *underlying consonant*, *underlying vowel* and *stress* for Théo) suggests that they do not acquire affrication in the same way, consistent with the idea that children are sensitive to different conditioning factors in the acquisition of phonological rules.

The next subsection examines overapplication of affrication to further assess whether the acquisition of affrication is the result of the acquisition of a phonological rule or the emergence of coarticulation.

Overapplication of affrication

The examination of overapplication is important in that it sheds light on whether or not children are making the correct generalizations about the input (e.g., Clahsen & Rothweiler, 1993; also Yang, 2002, 2016). Overapplication indicates that children are in the process of acquiring a phonological rule, rather than storing the input to which they are exposed in chunks (Pinker & Prince, 1988).

Both children produced a total of 117 items where overapplication of affrication is observed (58 for Clara, 59 for Théo).[8] Here, overapplication corresponds to all cases where an affricate is used without the phonological context for it. It can thus occur in two ways: an affricate is produced (a) when the underlying consonant is not /t,d/ (incorrect target), and/or (b) when the underlying vowel following the target consonant is not high front (incorrect trigger). The patterns described in this subsection are not presented relative to the periods listed in Table 3, as they are

[8]Théo regularly produces the words *taxi* 'taxi' and *coccinelle* 'ladybug' with [ts] instead of [ks] (24 productions in total). Since it is not possible to determine whether these productions result from overapplication of affrication or consonant assimilation, they are excluded from the analysis.

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observed throughout the data, although they become rarer (relative to the proportion of tokens by period) over time. Tables with counts of children's overapplication patterns are provided in the appendix.

Regarding (a), if children have not yet understood that affricates are in complementary distribution with /t,d/, they may produce an affricate in place of another underlying consonant. However, overapplication is most frequent with an underlying coronal stop, both for Clara (36/58, 62%) and Théo (33/59, 55.9%). In the remainder of cases, affrication is observed when the underlying consonant is a coronal fricative (19/58, or 32.7%, for Clara; 20/59, or 33.9% for Théo),[9] or a stop or fricative of another quality (Théo: /bebe/ → [d͡zəd͡ze] 'baby', 2;01.18; Clara: /fɑ̃tom/ → [t͡sɪtom] 'ghost', 1;09.28). Overapplication with an underlying coronal stop is illustrated in (4).

(4) Overapplication of affrication with coronal stops:

Production	Target form	Child/Age	Word	Gloss
dədʒo	dodo	Clara/1;05.17	*dodo*	sleep
kɔ̃t͡se	kɔ̃te	Clara/2;06.05	*conter*	to tell
tot͡ʃo	oto	Théo/2;07.13	*auto*	car
kɔ̃t͡sɑ̃	kɔ̃tɑ̃	Théo/2;08.02	*content*	happy

Note that the examples in (4) all exhibit an incorrect trigger (as per (b) above). In effect, most cases of overapplication involve underlying vowels that are not high front (52/58, or 89.6% for Clara; 46/59, or 77.9% for Théo). While overapplication occurs with virtually all the vowels in the QF inventory, it is more frequent with /e/ and /u/ for Clara (28/58, or 45.9%, and 10/58, or 17.2%, respectively), and /e/ and /ə/ for Théo (22/59, or 37.2%, and 10/59, or 16.9%, respectively). Overapplication with these underlying vowels suggests that children have some understanding about affrication being conditioned by specific vowel features – namely, height and backness – although they have not completely learned which must be the right feature combination yet. Overapplication with /e/ and /ə/ may be further explained based on acoustic similarities that could result in misperception by children: lax [ɪ] has a similar acoustic profile to /e/, while /ə/ is realized as a mid front rounded vowel (either as [ø] or [œ]) in QF (see e.g., Séguin, 2010).

However, it is possible that forms with a trigger vowel other than high front are repaired by the children. In other words, it is possible that children change the quality of the underlying vowel so that affricates are followed by a high vowel in their productions. The forms in (5) illustrate cases where an underlying vocoid other than /i,y,j,ɥ/ following a coronal stop is realized as high front AND affrication applies.

[9]Examples of affrication with an underlying coronal fricative include /isi/ → [it͡ʃi] (Clara, 1;05.04), and /wazo/ → [at͡so] (Théo, 2;07.22). While it could be argued that affrication with an underlying coronal fricative indicates incomplete acquisition of the process, this could be the result of children's difficulty with the production of sibilants (as reported, e.g., in the acquisition of English by Smith, 1973). Since most of the contexts of overapplication involve an underlying coronal stop, the manner of the target consonant does not seem to be a particular burden for the acquisition of affrication in QF.

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(5) Change in vowel quality and overapplication of affrication with non-high front vowels:

Production	Target form	Child/Age	Word	Gloss
d͡zɪ	de	Clara/2;02.06	*des*	some
æpɔt͡sɪ	apɔʁte	Clara/2;06.28	*apporter*	to bring
d͡zi	dø	Théo/2;06.29	*deux*	two
t͡sio	teo	Théo/2;10.24	*Théo*	Théo

Tokens with the profile of those in (5) account for 62% (36/58) of Clara's and 55.9% (33/59) of Théo's production of non-target-like affrication. The forms in (5) further support the idea that children do have an early understanding about the fact that affrication is conditioned by vowel quality – even if we assume that the non-target vowels are production errors, the fact that children affricated the preceding coronal stop in these cases is an indication that they notice the requirements for affrication in the language.

These patterns of overapplication indicate that affrication is the result of a phonological rule in QF. As discussed, children's non-target-like productions are not random, suggesting that they make (at least partially) correct generalizations about affrication from a relatively early age. I discuss the extent to which these observations for overapplication speak to the acquisition of affrication relative to branching onsets in the next section.

Discussion and conclusion

Examination of data produced by two QF-speaking children reveals that target-like affrication (i.e., affrication in obligatory contexts) is acquired LATER than target-like branching onsets, as hypothesized. At the same time, the patterns of overapplication observed in the data indicate that children make generalizations from an early age about which factors (i.e., vowel quality, consonant type) constrain the phenomenon. One question to consider is whether these patterns of overapplication actually indicate that children ACQUIRE affrication much earlier than what Figures 2 and 3 show.

This, however, does not seem to be the case, for two reasons. First, in contexts where affrication is expected, accuracy is very low during the first two periods for both children. In the case of Théo, accuracy increases regularly over time (Figure 2); in the case of Clara it does not surpass 55% (Figure 3). Although both children may understand to some extent the constraints on affrication relatively early (in line with e.g., White et al., 2008), they still fail to consistently apply the process in required contexts by the time they have acquired branching onsets (periods 2 and 3).

The second reason, which follows from the first, is related to the fact that affrication is a categorical phenomenon word-internally (Côté, 2014). QF-speaking children are therefore exposed to categorical evidence that affricates (but not [t,d]) occur before high front vowels in such positions. While this allows children to have an early understanding on how affrication is constrained, it may also lead them to alter the output to accommodate their emerging phonological representations. This is in effect observed in the data, particularly in productions where an underlying non-high vowel is realized as high and the coronal stop is realized as affricated (such as in

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[d͡zi] for *deux* 'two'; see (5)). Although these productions signal that categorical evidence may lead to early awareness of the constraints underlying affrication, they also show that acquisition is not yet complete.

As previously mentioned, the existence of overapplication is consistent with the idea that children are on their way to acquire a phonological rule, which contrasts with the possibility that affrication is acquired once children are able to produce coarticulated strings. It remains to be examined whether the overapplication patterns observed in the data are comparable with other cases of overapplication or overgeneralization of a phonological rule. A comparison can be drawn between cases of overapplication such as [dəd͡zo] (for *dodo*) and [d͡zi] (for *deux*) and overapplication of other phonological rules, such as stress and vowel harmony. It has been shown that, in languages with both trochaic and iambic stress patterns (such as Spanish), children tend to overgeneralize the trochaic pattern to iambic words (Lleó & Arias, 2007). In the case of vowel harmony, Hungarian-speaking children tend to overapply rounding harmony to invariant suffixes (MacWhinney, 1978). These observations suggest that overapplication not only is part of the process of acquiring a rule, but it also reflects children's knowledge of the phonological grammar.

These observations may also be extended to the acquisition of variable phenomena that apply probabilistically, such as -ing variation and -t/d deletion in English (Roberts, 1994, 1997). In these cases, although children may not mirror adults' behavior completely (especially in the case of -t/d deletion), their patterns of application reflect an (at least partial) understanding of the constraints that regulate the phenomena. This suggests that children's grammars are able to accommodate variation in a similar way to adults' grammars.

One question that remains is whether the acquisition of affrication is in effect comparable with the acquisition of branching onsets. In Rose (2000, 2002, 2003), branching onsets were marked as accurate whenever an onset string with the target number of segments was realized, regardless of whether the individual segments in the onset were target-like (see (3)). One could thus argue that children's accuracy for branching onsets is magnified under this approach, which could explain their acquisition of affrication occurring later. However, it should be noted that, in the data in Rose (2000, 2002, 2003), branching onsets with a non-target-like segment usually involve issues with voicing rather than issues with place or manner. Despite inaccuracies in individual segments of branching onsets, these productions evidence that children's representation of the onset domain already contains multiple slots. In the present analysis, all tokens with an affricate were coded as exhibiting affrication (including [t͡ʃ,d͡ʒ,t͡ɕ,d͡ʑ], which are not target-like in adult QF in the contexts under examination), as a way to be able to draw comparisons with Rose's analysis.

In summary, the present investigation has shown that the two QF-speaking children under analysis, Clara and Théo, acquire branching onsets before affrication. This is consistent with the proposal that, in a language where non-contrastive affrication arises due to complementary distribution, the constraints on the distribution of affricates are more onerous for acquisition than the constraints on onset complexity. In other words, for affrication in QF, it is not complexity at the segment VERSUS the syllable that affects order of acquisition (unlike in German and Spanish; Lleó & Prinz, 1997); instead, mastering the constraints on complementary distribution is more difficult for children than acquiring complexity at the syllable level. For both children, accuracy improves over time, with Théo surpassing 75% accuracy in period 4, one period after his acquisition of branching onsets in all positions.

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The results have also shown that different phonological factors influence children's accuracy. The observation that children are affected differently by distinct predictors related to the shape of the underlying representations suggests that they are not equally sensitive to all the phonological factors conditioning affrication, which in turn further supports the idea that the acquisition of affrication in QF corresponds to the acquisition of a phonological RULE, not the development of coarticulation in the children's speech.

This analysis focused on the acquisition of affrication in categorical contexts based on longitudinal data from two QF-speaking children. One question that remains unaccounted for is what children's performance would be in contexts of juncture between a word-final /t,d/ and a word-initial high front vowel. As previously mentioned, affrication is variable in these contexts (Côté, 2014). One possibility is that, given categorical evidence for affrication word-internally, children might overgeneralize affrication in these contexts, producing it more frequently than adults. This issue is left for future research.

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Appendix

Overapplication errors by child (counts only) per period. V refers to any vowel other than a high front vocoid or /e/. C refers to any consonant other than /t/, /d/ or sibilant.

Théo:

	2;00–2;04	2;05–2;08	2;09–3;00	3;01–3;04	3;05–3;08	3;09–4;00
t + e	NA	1	1	NA	3	NA
t + V	3	3	1	2	1	5
d + e	NA	NA	1	1	2	5
d + V	NA	2	1	NA	1	NA
sibilant + V	2	4	3	1	5	5
other C + V	3	NA	1	2	NA	NA
Total	8	10	8	6	12	15

Clara:

	1;03–1;07	1;09–1;11	2;00–2;03	2;05–2;07
t + e	NA	NA	1	6
t + V	NA	5	2	2
d + e	NA	NA	9	6
d + V	1	NA	3	1
sibilant + V	5	6	5	3
other C + V	NA	2	1	NA
Total	6	13	21	18

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