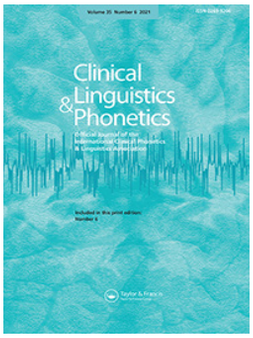

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Coda consonant production in French-speaking children

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ABSTRACT

This study examined coda production in French-speaking children, aged 2;6 to 6;10 (n = 141). The primary aim was to provide normative information on coda production with a large group of children. The secondary aim was to investigate factors which influence coda production such as age, manner and place of articulation, word length, word position, and bilingualism. Children took part in a word-naming task in which they produced words containing word-final and -medial codas. Results indicated that French-speaking children, as young as 2;6, produce word-final codas with a high degree of accuracy (i.e. 80%). Age had minimal effects on coda presence (i.e., whether a coda was realized or not) but it did influence coda accuracy (i.e. whether a coda was realized target-like). Older children had better coda accuracy scores than younger children. Manner of articulation influenced coda production: the younger children had the lowest scores for liquid and fricative codas whereas the older children, for fricative codas. A closer examination of coda production according to voicing revealed it was voiced obstruent codas which obtained low accuracy scores across age groups. Word-length influenced coda realization with the youngest age group producing codas more often in one- versus two-syllable words. Children produced codas more often in word-final versus word-medial position with the greatest differences evident in the youngest children. Bilinguals obtained better coda scores than monolinguals at the youngest ages and poorer ones at the oldest ages. The study concludes with a discussion of the clinical implications of the findings.

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French; codas; child speech; bilingualism

During the last two decades or more, researchers have investigated different phonological structures in child speech. A particular focus has been given to coda consonants in view of the fact that they are more marked than syllable onsets (Demuth, 1996) and are often acquired late, especially in those languages in which codas are infrequent (Lleó et al., 2003 on Spanish codas). Certain themes have dominated research on coda development including whether children produce obstruent before sonorant codas (Fikkert, 1994) and whether factors such as stress, word length, and word position influence the realization of codas (Demuth et al., 2006; Kirk & Demuth, 2006). The findings from these studies are important because they inform us on how linguistic properties influence coda production across languages as well as provide information on phonological intervention, given that codas are subject to error in children with speech sound disorders.

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Supplemental data for this article can be accessed on the publisher's website.

This study focuses on the development of codas in French-speaking children, aged 2;6 to 6;10. Although several studies discuss coda production in French-speaking children (Brosseau-Lapré & Rvachew, 2014; Hilaire-Debove & Kehoe, 2004; MacLeod et al., 2011b; Rose, 2000, 2003), few studies have examined coda production in a large group of children. Our study aims to provide normative data on coda production and address whether factors such as sonority/manner of articulation[1], place of articulation, word length, and word position influence the production of codas. The data were collected in Geneva, Switzerland, where many bilingual children reside. Thus, another aspect of the study is to examine whether bilinguals differ from monolinguals in coda production. In the remaining sections of the *Introduction*, we provide a description of coda consonants in French, examine factors which influence coda production, and focus on studies which have examined codas in French.

Codas in French

Closed syllables are infrequent in French. The percentage of closed syllables in written text is 24% according to Delattre and Olsen (1969). Others report lower percentages of closed syllables in spoken speech, namely, 16% (Adda-Decker et al., 2005). French allows all manners and places of articulation of codas in word-final position, as shown in (1) and (2).

(1) Examples of different manners of articulation of word-final codas in French.

a. Stop	/t/	carotte	/kaˈʁɔt/	"carrot"
b. Fricative	/ʃ/	cloche	/klɔʃ/	"bell"
c. Nasal	/m/	dame	/dam/	"lady"
d. Liquid	/l/	cheval	/ʃəˈval/	"horse"
e. Glide	/j/	feuille	/fœj/	"leaf"

(2)Examples of different places of articulation of word-final codas in French.

a. Labial	/p/	lampe	/lɑp/	"lamp"
b. Coronal	/t/	bottes	/bɔt/	"boots"
c. Dorsal	/k/	lac	/lak/	"lake"

French also allows codas in word-medial position, as shown in (3).

(3)Examples of word-medial codas in French

a. Stop	/k/	docteur	/dɔkˈtœʁ/	"doctor"
b. Fricative	/s/	casquette	/kasˈkɛt/	"cap"
c. Liquid	/r/	tortue	/tɔʁˈty/	"tortoise"

Several authors propose that word-final consonants are not codas but are onsets of empty-headed syllables (Almeida, 2014; Goad & Brannen, 2000, 2003; Kaye, 1990; Kaye et al., 1990; Piggott, 1999; Rose, 2000, 2003). Views differ as to whether word-final codas are always syllabified as onsets (Kaye et al., 1990) or whether they are syllabified as onsets in certain

[1]By sonority/manner of articulation, we refer to the distinction obstruent versus sonorant or to differences among the manner class (stop, fricative, nasal, liquid, glide).

languages only (Piggott, 1999). Goad and Brannen (2003) propose that children syllabify word-final consonants as onsets regardless of their status in the language being applied. Phonetic evidence includes the presence of word-final epenthetic vowels, aspirated final stops and lengthened final consonants in the speech of young children. In addition, word-final codas are often acquired before word-medial ones, a finding which can be explained by the fact that codas in word-final and -medial positions have different structural representations: only word-medial are true codas. Rose (2003) provides a modified account of Goad and Brannen (2003) proposal, arguing that segmental representation and distributional evidence help to determine whether children syllabify word-final consonants as onsets or codas. He observes that, across languages, codas prefer segments that are placeless or restricted in place. In his study of two French-speaking children, he reported that one child represented [ʁ] as placeless and consequently syllabified it as a coda whereas the other child represented it as dorsal and syllabified it as an onset. Rose (2003) also interprets findings in Spanish in which word-medial consonants may be acquired before word-final ones (Lleó, 2003; see later discussion) as consistent with the notion that place of articulation restrictions on codas in Spanish lead some children to syllabify them as codas.

While acknowledging the ongoing debate on the representation of codas, we nevertheless adopt a coda representation of word-final consonants. Our analyses pertain to the surface realization of codas and not to their underlying structural representations. Second, acoustic analyses suggest that at least some children have coda consonant representations for word-final consonants. Yuen et al. (2015), in an acoustic analysis of a single English-speaking child's speech between the ages of 1;3 and 1;5, found that the child treated the C2 of CVC and CVCV target words differently, producing the C2 with longer closure duration for the monosyllables than the disyllables, consistent with a coda interpretation of final consonants for this child.

Factors which influence coda production

The influence of sonority/manner of articulation

Early accounts of syllable structure development proposed that obstruents appear before sonorants in coda position (Fikkert, 1994). By producing obstruents first, children were seen to create a maximal sonority contrast between the nucleus and coda. Several studies have found support for this order of acquisition (Almeida, 2011; Demuth et al., 2006). Demuth et al. (2006) reported that three out of four English-speaking children acquired stops and fricatives before nasals and liquids.

In fact, children by acquiring obstruents first are going against general markedness principles in which sonorants are preferred in coda position. Zamuner et al. (2005) conducted a frequency analysis of codas across 35 adult languages and found that sonorant codas were preferred. This is consistent with Zec's (1995) typology of codas in adult languages based on sonority constraints. Nevertheless, when Zamuner et al. (2005) examined the codas present in the production of CVC words by English-speaking children, no clear pattern of sonorants first was observed: [t, d, k, n] were the earliest acquired codas; [b, f, r, z] were the latest. The pattern was consistent with the frequency of codas in the input to the children. Other studies have also not supported a simple obstruent versus sonorant dichotomy in coda acquisition. Kehoe and Stoel-Gammon (2001) when studying coda development in English-speaking children found that voiceless obstruents and nasals

were acquired as codas before voiced obstruents and liquids (see also Bernhardt & Stemberger, 1998). In sum, studies are divided as to what is the typical order of coda acquisition in terms of sonority or manner of articulation.

The influence of place of articulation

Place of articulation may also be relevant to children's coda development. Fikkert and Levelt (2008) examined children's earliest productions in terms of the development of place features. They observed that when consonants could vary within a word (in a CVC form), they did so in a very restricted fashion in terms of place variegation: at first C_1 was labial and C_2 was coronal; later, final dorsals were allowed and, only later, final labials. This would suggest a developmental order of coronal codas before dorsal and labial.

Zamuner et al. (2005) also examined place of articulation of codas across 35 adult languages. They observed that coronals as codas were preferred across languages. They also observed that they were among the earliest codas produced by English-speaking children. Nevertheless, other non-coronal codas were also produced early such as /k/ and /m/.

As noted above, Rose (2003) appeals to place when explaining why some children syllabify final consonants as codas or onsets of empty headed syllables. He observed that placelessness or place restrictions on codas may lead some children to syllabify word-final consonants as codas. Overall, the findings are consistent with a preference for coronal codas in acquisition.

The influence of stress, word length, and word position

Several studies have examined the influence of stress, word length and word position on children's coda development (Demuth et al., 2006; Kirk & Demuth, 2006; Prieto & Bosch-Baliarda, 2006). One common finding is that codas are produced more accurately in stressed than in unstressed syllables (Borràs-Comes & Prieto, 2013; Kirk & Demuth, 2006; Prieto & Bosch-Baliarda, 2006). For example, Kirk and Demuth (2006) investigated English-speaking two-year-olds' productions of coda consonants in novel two-syllable words varying in stress (e.g.ˈCVCCVC vs. CVCˈCVC). They found that codas were more accurately produced in stressed versus unstressed position in both word-medial and – final position.

As for the influence of word length on coda production, different findings have been reported. Kirk and Demuth (2006) documented a strong effect of word length on coda production in English. Codas were more accurately produced in monosyllables versus bisyllables, while controlling for stress (e.g. CVC vs CVˈCVC or CVCˈCVC). Borràs-Comes and Prieto (2013) did not document the same effect, however. There were no differences between the production of codas in monosyllables versus bisyllabic iambs in Spanish and Catalan bilinguals. The authors argued that the strong effect of word-length in English may relate to the high percentage of monosyllables in this language (Roark & Demuth, 2000).

Many authors report that codas are produced more accurately in word-final than – medial position. This has been found to be the case for English (Kirk & Demuth, 2006), Dutch (Fikkert, 1994), French (Rose, 2000), and Catalan (Borràs-Comes & Prieto, 2013). In Spanish, the findings are equivocal. Lleó (2003) found that medial codas were acquired before final ones in two Spanish-speaking children from Madrid. More recent findings

either report no difference between coda acquisition in medial and final acquisition (Núñez-Cedeño, 2007) or report a complicated pattern such as earlier emergence in final but earlier mastery in medial position (Polo, 2018). In sum, findings on coda development across several languages indicate that codas are acquired earlier in stressed versus unstressed syllables and in word-final versus -medial position (with the possible exception of Spanish). The influence of word length on coda development has been reported for English but not for Catalan and Spanish.

Studies in French on coda development

What do we know about coda development in French? Hilaire-Debove and Kehoe (2004) investigated the influence of word length and manner of articulation on word-final coda acquisition in 15 French-speaking children, aged 1;8 to 2;8. They found an effect of word length: children realized codas more often in monosyllables versus disyllables. In contrast, they did not observe a simple pattern of obstruents being acquired before sonorants in coda position. To examine the effect of manner of articulation on coda production, they divided the participants into three groups in terms of the percentages of codas accurately produced. The first group (n = 2) hardly produced codas at all. The second group (n = 5) realized codas correctly 58% of the time; they produced voiceless obstruents (i.e. stops and fricatives), nasals and glides more accurately than voiced obstruents and liquids. The third group (n = 8) realized codas correctly 81% of the time; they produced plosives, liquids and nasals before glides and fricatives. Thus, an important finding was that there were differences in the influence of manner of articulation on coda production according to the children's stage of coda development.

Gaborieau and Sagaspe (2011) investigated word-final coda production in 30 French-speaking children, aged 3;0 to 3;1, using a similar methodology to that of Hilaire-Debove and Kehoe (2004). The overall percent correct production of codas in this group was 83%: Liquids (88%), stops (87%), glides (87%) and nasals (84%) were all produced significantly better than fricatives (77%). They also found that voiceless obstruents were produced more accurately than voiced obstruents (88 vs. 73%). Omission of codas at this age was infrequent and was present mainly in liquids. The effect of word length was not significant, contrary to the findings of Hilaire-Debove and Kehoe (2004) with younger children.

Apart from these two studies on European French-speaking children, information on coda acquisition can be gleaned from studies on speech sound development in Canadian French. MacLeod et al. (2011b) conducted a study of consonant production in Canadian French pre-school children (156 children, aged 20 to 53 months). They found that the earliest sounds mastered in word-final coda position were /t, n/ and the latest sounds were /b, d/. The liquids /ʁ, l/ were also mastered early (i.e. by 30 to 35 months). Rvachew et al. (2013) describe the results of a screening test for French Canadian children. They did not report findings on word-final consonants; they did indicate, however, that word-medial codas in words such as garderobe /gaʁdəˈʁɔb/ "wardrobe" and escalier /ɛskaˈlje/ "stairs" were susceptible to omission in children, through to the age of 6 to 7 years.

In sum, a review of the literature indicates that French-speaking children acquire word-final codas relatively easily. A sub-sample of children in Hilaire-Debove and Kehoe's (2004) study, aged 1;8 to 2;8, produced codas 81% of the time. None of the studies report a simple pattern of obstruents being acquired before sonorants; rather they report a complex pattern with voiceless obstruents being acquired early and fricatives being acquired late. Only one

study, Hilaire-Debove and Kehoe (2004), found an influence of word-length on the presence of codas. Few studies have compared medial and final codas but observations by Rvachew et al. (2013) indicate that word-medial consonants may be deleted through to 7 years.

Influence of bilingualism on coda production

Our sample of children includes monolinguals and bilinguals, so a final consideration is whether bilingualism influences the production of codas. Several studies have examined coda production in bilingual children, from the perspective of cross-linguistic interaction. They report that bilingual children may experience acceleration in coda production in one language due to the influence of the other language which contains more frequent and complex codas. Such a pattern has been observed in the Spanish of Spanish-German and -English bilinguals (Keffala et al., 2018; Lleó et al., 2003). Bilingual children may also evidence delay in one language if the other language contains less frequent and complex codas. Such a pattern has been observed in Spanish-English bilinguals acquiring English (Gildersleeve-Neumann et al., 2008) as well as in a French-Portuguese child acquiring word-medial codas in French (Almeida et al., 2012). We have studied cross-linguistic interaction in the current data set and found that the complexity and frequency of codas in the child's L1 (i.e. language spoken at home which is not French) influenced the child's production of codas in French at a younger but not at an older age; factors such as lexical development played a stronger role in the older group (Kehoe & Girardier, 2020; Kehoe & Havy, 2019).

In this study, we do not return to the theme of cross-linguistic interaction. Rather, we are interested in examining whether bilinguals, who speak a diverse set of languages, differ from monolinguals in their production of codas, possibly necessitating the need for separate norms. Studies which have examined bilinguals on global measures such as percent consonants or vowels correct (PCC, PVC) have yielded varied results. Bilinguals may do better (Goldstein & Bunta, 2012; Grech & Dodd, 2008), less well (Gildersleeve-Neumann et al., 2008; Law & So, 2006), or behave similarly to monolinguals (MacLeod et al., 2011a). Thus, the necessity of generating separate norms for bilinguals remains uncertain. We also examine whether bilinguals differ from monolinguals in the production of codas from different manner classes. Certain consonant classes, such as liquids, in particular, rhotics, may be more susceptible to monolingual-bilingual differences than others due to variation in their phonetic realization across languages (e.g. alveolar approximant in English; alveolar trill in Spanish; uvular approximant or fricative in French). We wish to explore whether such differences are present in the current dataset.

Summary and predictions

In sum, a handful of studies provides information on coda production in French. However, few studies have tested codas in many children across a wide age range. The primary purpose of the study is to provide preliminary normative data on coda production in French-speaking children, aged 2;6 to 6;10. A secondary aim is to examine which factors, amongst the following, sonority/manner of articulation (also voicing), place of articulation, word length, and bilingual status influence coda acquisition. We do not consider linguistic stress as a factor since stress and word-position are confounded in French: word-final codas

appear in the final stressed syllable. Our focus is on word-final codas; however, we also compare the production of /r/ and /s/ in word-final and – medial position[2]

Based on literature findings, we predict:

(1) There will be no simple pattern of obstruents being acquired before sonorants in coda position; however, manner of articulation will significantly influence coda production with certain manners of articulation (e.g. stops, nasals) being acquired before others (e.g. fricatives).
(2) Coronal codas will be acquired before dorsal and labial codas.
(3) Codas will be acquired more easily in short versus long words. This prediction is based on Hilaire-Debove and Kehoe's (2004) findings with two-year-olds. Studies with older French children have not found an effect of word-length on coda production; thus, we consider the possibility that word length does not influence coda production in the older age groups.
(4) Codas will be acquired more easily in word-final than word-medial position.
(5) Due to varied findings, we do not make strong predictions on whether bilinguals will have lower or higher percent correct production of codas than monolinguals (Hambly et al., 2013). We predict, however, that bilinguals may differ from monolinguals in certain manner of articulation categories.

Method

The data come from two studies: Kehoe and Havy (2019) and Kehoe and Girardier (2020). In the first study, 40 children, aged 2;6, were tested at the university laboratory. In the second study, 101 children aged 3 to 6 years were tested at their kindergartens or public schools. We refer to the two different datasets as: Group 2;6 and Group 3 to 6.

Participants

Group 2;6 include 40 French-speaking monolingual and bilingual children, aged 2;6 years (± 14 days). Forty-six children were originally tested but six children were excluded due to lack of cooperation (n = 4), a history of developmental delay (n = 1), or a low vocabulary score (n = 1). The final number of children included 17 monolinguals (7 females) and 23 bilinguals (13 females). Percent exposure to French and to other languages was determined by the Language Exposure Questionnaire (Bosch & Sebastián-Gallés, 1997). Monolinguals were designated as children who received 90% to 100% exposure to French whereas bilinguals were those who received 80% or less exposure to French.

Group 3 to 6 included 101 French-speaking children (52 females), aged 2;11 to 6;10, who attended kindergarten or public schools in Geneva. The original sample tested was 108 children, but seven children were excluded due to having received speech therapy (n = 4), not participating in the test procedure (n = 2), and for having missing information (n = 1). The mean age of the

[1,5] A careful examination of words in the IFDC (Kern & Gayraud, 2010) and DLPF version 3 (Bassano et al., 2005) shows that /r/ is the most frequent word-medial coda followed by /s/.

monolinguals was 5;0 and the mean age of the bilinguals was 5;2. There was no significant difference in age between the monolinguals and the bilinguals on the basis of a two-tailed t-test (t (99) = −1.0, p =.32).

Bilingual status in Group 3 to 6 was determined by a parent questionnaire (loosely based on the PABIQ, Tuller, 2015) in which parents indicated whether their child spoke another language at least 30% of the time in addition to French.[3] They were required to indicate which language the child spoke at home and with whom, and at what age the child had acquired French. Parents were also required to judge the language usage of French and the other language on a scale from 1 to 5. In addition, they indicated whether they had any concerns about their child's speech and language development. Information provided in the questionnaire revealed that 64 of the 101 children were bilingual. They had all acquired French before the age of 3 years except for one child who started learning French at 3;4.[4] The children were predominantly dominant in French (n = 36). The remaining were dominant in the home language (n = 7) or were balanced bilinguals (n = 20). In one case, parents did not complete the question on language usage.

In Group 2;6, six of the 23 bilinguals were trilinguals. In Group 3 to 6, 10 of the 64 bilinguals were trilinguals. In the current study, we do not make a distinction between bilingual or trilingual input. Appendix A and B provide information on the monolingual and bilingual participants, including age and gender, and in the case of the bilinguals, languages spoken and their percent exposure to or dominance in French.

Stimuli

The stimuli for Group 2;6 included 27 words (monosyllabic and disyllabic) containing word-final codas, and the stimuli for Group 3 to 6 included 49 words (one to four syllables in length) containing word-final codas, 8 words containing word-medial /r/, and 5 words containing word-medial /s/. The majority of words can be found in the IFDC, l'Inventaire Français du Développement Communicatif (IFDC) (Kern & Gayraud, 2010) and/or in the Developpement du langage de production en français (DLPF) version 3 (31–36 mois) (Bassano et al., 2005). In addition, any words spontaneously produced during the session (i.e. not included in the stimulus list) which contained word-final codas or word-medial /r/ or /s/ could be included in the data-set with the proviso that they were produced by multiple children.

The stimuli were selected to target word-final consonants across all manners of articulation. However, since the data were collected as part of a larger study, it was not possible to target all word-final consonants equally. Four word-final consonants (e.g. k, g, v, ɲ) were not targeted to a sufficient degree to be included in the final dataset. In addition, only /r/ and /s/ were sampled sufficiently to be included in the study of medial codas. The stimulus words are listed in Appendix C.

[3]We employed different criteria for designating a child as bilingual in Group 3 to 6 as compared to Group 2;6 (30% vs. 20%). This was because we did not conduct interviews with the parents of the older children and, thus, employed a stricter criteria to ensure that the children were bilingual.

[4]This child had similar results to the other bilingual children, who have received language exposure before 3;0 suggesting that the slightly later age of acquisition did not influence phonological production.

Procedure

Both groups of children took part in a production task of approximately 20 to 30 minutes in which they were encouraged to name pictures and objects of the stimulus words. Group 2;6 was tested in the speech laboratory at the University of Geneva and Group 3 to 6 was tested in a quiet room in the children's kindergarten or school. Children in Group 2;6 interacted with a native French-speaking experimenter and, on occasion, one of their parents, whereas children in Group 3 to 6 interacted with two native French-speaking experimenters. The testers were instructed to elicit spontaneous productions of stimulus words but, when this was not possible, to obtain productions either through direct or delayed imitation. Children in Group 2;6 produced on average 35 words containing word-final codas (sd. = 11, range = -10–62), whereas children in Group 3 to 6 produced on average 67 words containing word-final consonants (sd. = 10, range = 41–104) and 7 (sd. = 1, range = 4–11) and 4 (sd. = 1, range = 2–8) words containing word-medial /r/ and /s/ respectively.

Data-transcription

Children's speech was recorded with a portable digital tape-recorder (Group 2;6: Marantz PMD620; Group 3 to 6: MARANTZ, TASCAM DR-2d) and unidirectional condenser microphone. Using Phon, a software program designed for the analysis of phonological data (Rose et al., 2006), each child's WAV file was segmented, and stimulus words were identified and transcribed. In both groups, French-speaking under-graduate and graduate students, who had experience in phonetic transcription performed the analyses. They transcribed each child's productions in broad phonetic transcription. The transcribed data were transferred to Excel and coded according to the presence and accuracy of codas. Productions containing target word-final codas were coded as correct for coda presence when a coda was present regardless of whether it was segmentally correct (e.g. cloche /klɔʃ/ "bell" as [klɔs]) and as incorrect when a coda was absent (e.g. (e.g. cloche as [kla]). They were coded as correct for coda accuracy when the coda was segmentally correct (e.g., cloche as [klɔʃ]) and as incorrect when the coda was absent or was not segmentally accurate (e.g. (e.g. cloche as [kla] or [klɔs]).

Reliability

Three participants in Group 2;6 and 12 participants in Group 3 to 6 data were re-transcribed by a second transcriber using the Blind Transcription function of the Phon program. Point-to-point agreement in terms of consonant transcription (excluding voicing errors) was high (96%) in Group 2;6 and good (87.5%) in Group 3 to 6.

Coding and statistical analyses

Data were analysed using mixed effects logistic regression. The analyses were performed using R statistical software (R Development Core Team, 2015) and the lme4 package (Bates et al., 2015) for mixed effects models. Comparisons were made using likelihood ratio tests (LRT) which yield a chi-squared statistic. To determine differences between groups, we employed Tukey multiple comparisons.

Fixed effects included age in months (for group 3 to 6 only), manner of articulation (stop, fricative, nasal, liquid, glide), place of articulation (labial, coronal, dorsal)[5], word length (one, two, three syllables)[6], and bilingual status (monolingual, bilingual). Gender was initially included but it did not prove significant in any of the statistical models and was subsequently excluded to avoid over parameterization. We also did not include language exposure/dominance as variable due to the large number of predictor variables and the problems of achieving model convergence. We did include, however, the interaction between manner of articulation and bilingualism since we posited that the effect of bilingualism could vary according to manner of articulation, as suggested above. The random part of the model included random intercepts for participants and items. The analyses were conducted on two dependent variables: coda presence and accuracy. We ran two separate models: one for Group 2;6 and one for Group 3 to 6. The reason for this was that the two groups were tested in separate studies which were characterized by methodological differences. In Group 2;6, age as factor was not necessary since all children were the same age whereas in Group 3 to 6, children varied in age. Children in group 2;6 produced only monosyllables and disyllables whereas children in group 3 to 6 produced three-syllable words as well.

Results

Word-final consonants in Group 2;6

The first model examined the effect of manner of articulation, place of articulation, word length, bilingualism, and the interaction between manner and bilingualism on coda presence in Group 2;6. Results indicated that word length had a significant effect ($\beta = -.84$, $\chi^2(1) = 8.22$, $p = .004$). Codas were produced more often in one- versus two-syllable words. In addition, there was a significant interaction between manner of articulation and bilingualism ($\chi^2(4) = 26.05$, $p < .001$). Tukey pairwise comparisons (with corrections included) indicated that bilinguals realized codas more often than monolinguals for target liquids ($z = 4.10$, $p = .002$). Analyses also indicated that place of articulation had a significant effect ($\chi^2(2) = 6.56$, $p = .038$) on coda production; however, when Tukey pairwise comparisons were applied, no contrast emerged as significantly different. A second model examined the influence of these factors on coda accuracy. Results indicated that only the interaction between bilingualism and manner of articulation was significant ($\chi^2(4) = 19.64$, $p < .001$). Tukey pairwise comparisons revealed that bilinguals were more accurate than monolinguals in their production of target liquids ($z = 3.44$, $p = .02$). The results of the statistical models are presented in Appendix D.

To illustrate these findings, we show the results for coda presence and accuracy according to word length and manner in Tables 1 and 2 respectively. As can be seen in Table 1, children omitted fewer codas in monosyllables versus disyllables, but produced codas with similar accuracy levels in both sets of words (approximately 80%). Table 2 shows that percent coda presence ranged from 82% for liquids through to 92% for stops and nasals and percent coda accuracy ranged from 74% to 75% for liquids and fricatives through

[5]One problem with the analyses of place of articulation is that final /k, g/ were not sampled in the data set. Thus, the only phoneme with "dorsal" place of articulation was the rhotic [ɹ].
[6]Children also produced four syllable words but since this category included the word helicopter only, we did not include it.

Table 1. Percent production of word-final codas organized according to word length (in number of syllables) in French-speaking children, aged 2;6.

		%coda presence		%coda accuracy	
No. of syllables	Mean no. of words	Mean	sd.	Mean	sd.
1	13	93.39	9.33	79.53	12.78
2	22	88.80	16.16	80.68	16.13

Table 2. Percent production of word-final codas according to manner categories in French-speaking children, aged 2;6.

		%coda presence		%coda accuracy	
Manner categories	Mean no. of words	Mean	sd.	Mean	sd.
Stop	9	92.25	13.66	82.18	16.59
Fricative	12	90.84	16.65	75.12	21.32
Nasal	4	92.33	16.41	85.55	23.83
Liquid	6	81.65	22.72	74.73	31.69
Glide	3	88.64	23.16	84.04	27.88

to 84–85% for glides and nasals. Since there was a significant interaction between manner and bilingualism, we also present results for monolinguals and bilinguals organized according to manner categories (for coda accuracy only; see Table 3). Bilinguals obtained better coda accuracy than monolinguals across all manner categories except for stops, with the strongest differences being for liquids (17%). Given that place of articulation also emerged as significant in the model, we show the coda accuracy and coda presence results according to place in Table 4. These results should be interpreted with caution since velar stops were not sampled in the data and also because children produced coronal codas more often than labial and dorsal. Keeping these factors in mind, Table 4 shows that coronal codas were omitted less frequently and had better accuracy results than codas of other places of articulation.

Table 3. Percent accuracy of word-final codas according to bilingual status and manner of articulation in French-speaking children, aged 2;6.

	Monolinguals			Bilinguals		
		%coda accuracy		Mean no. words	%coda accuracy	
Manner	Mean no. words	Mean	sd.		Mean	sd.
Stop	10	85.81	11.74	9	79.50	19.23
Fricative	13	69.99	22.16	11	78.91	20.33
Nasal	4	80.60	28.50	5	89.20	19.58
Liquid	6	65.15	26.08	5	81.81	34.09
Glide	3	78.96	32.47	3	87.73	24.13
ALL	36	76.72	13.75	33	82.80	14.89

Table 4. Percent production of word-final codas according to place categories in French-speaking children, aged 2;6.

		%coda presence		%coda accuracy	
Place categories	Mean no. of words	Mean	sd.	Mean	sd.
Labial	5	88.71	21.21	74.49	31.89
Coronal	26	91.87	11.40	82.85	14.33
Dorsal[a]	4	81.58	27.23	73.17	36.32

a Dorsal category includes only productions of uvular /r/.

Word-final consonants in Group 3 to 6

In the next analyses, we examined the effect of manner and place of articulation, word length, bilingualism and age (coded in months) on coda presence and accuracy in Group 3 to 6. Initial analyses indicated that the interaction between bilingualism and manner was not significant and, thus, it was removed from the model to avoid over-parametrization. Using a simplified model with main effects only, results indicated that one factor influenced coda presence: manner of articulation ($\chi^2(4) = 16.00$, $p = .003$). Tukey pairwise comparisons revealed that codas were realized less frequently with target glides than with stops ($z = -3.39$, $p = .006$). We ran a second model using coda accuracy as dependent variable. Three factors were significant: age ($\beta = .26$, $\chi^2(1) = 7.03$, $p = .008$), bilingual status ($\beta = .56$, $\chi^2(1) = 7.43$, $p = .006$), and manner of articulation ($\chi^2(4) = 27.16$, $p < .001$). Older children and monolinguals produced codas more accurately than younger children and bilinguals. Tukey pairwise comparisons indicated that fricatives were produced less accurately than liquids ($z = -4.41$, $p < .001$) and nasals ($z = -3.70$, $p = .002$) and marginally less accurately than stops ($z = -2.68$, $p = .058$). The results of the statistical models are presented in Appendix D.

To illustrate these findings, we present the findings on coda presence and accuracy according to age, manner and bilingual status. To simplify the presentation on age effects, we group children into one year intervals: 3 (2;11–3;11), 4 (4;0–4;11), 5 (5;0–5;11), and 6 (6;0–6;10) and also include Group 2;6 for comparison. As Table 5 shows, at age 2;6, codas were present 89% of the time and accurate 79% of the time. By age 3, they were present 99% of the time and this percentage remained constant through to age 6. At age 3, they were accurate 88% of the time and this percentage increased to 93% at age 4 through to 6. Table 6 presents coda production results according to manner of articulation. In the 3 to 6 group, children rarely omitted codas. Nevertheless, as the statistical results indicated, glides were omitted significantly more often than stops: 95% versus 100% for coda presence. The accuracy rates of manner categories were 93% or greater except for fricatives, which had a mean accuracy of 81%. Table 7 shows the coda results for monolinguals and bilinguals

Table 5. Percent production of word-final codas according to age in French-speaking children.

			%coda presence		%coda accuracy	
Age	No. of Children	Mean no. of words[a]	Mean	sd.	Mean	sd.
2;6	40	35	89.06	13.08	78.97	16.07
3;0	19	63	98.59	1.63	88.33	6.80
4;0	18	65	98.97	1.09	93.39	4.05
5;0	39	68	98.64	1.81	93.18	5.38
6;0	25	67	98.83	1.68	92.64	5.04

Table 6. Percent production of word-final codas according to manner categories in French-speaking children, aged 3 to 6.

		%coda presence		%coda accuracy	
Manner categories	Mean no. of words	Mean	sd.	Mean	sd.
Stop	10	99.90	1.00	94.85	8.04
Fricative	18	98.85	2.64	80.73	17.07
Nasal	15	99.35	2.11	98.75	3.18
Liquid	18	98.59	3.38	97.63	5.01
Glide	5	94.96	10.42	93.00	11.79

Table 7. Percent accuracy of word-final codas according to bilingual status and age in French-speaking children, aged 2;6 and 3 to 6.

		Monolinguals			Bilinguals	
Age	No of children	Mean	sd.	No. of children	Mean	sd.
2;6	17	76.72	13.75	23	82.80	14.89
3;0	7	87.04	7.60	12	89.09	6.52
4;0	8	94.29	3.76	10	92.67	4.32
5;0	16	95.73	3.55	23	91.40	5.78
6;0	6	94.91	5.23	19	91.92	4.91

according to age. Once again, age group 2;6 is included for comparison. A significant main effect for bilingualism was reported for Group 3 to 6, but, as Table 7 indicates, monolinguals obtained higher scores than bilinguals only as of 4 years.

The influence of voicing on word-final consonants

Some studies indicate that voiced obstruents are acquired later than voiceless obstruents in coda position (Gaborieau & Sagaspe, 2011; Hilaire-Debove & Kehoe, 2004). Thus, we also conducted analyses on a reduced database (limited to words containing word-final stops and fricatives) to determine whether the effect of voicing was significant. We examined the effect of voicing (-/+ voice) on coda presence and accuracy in Group 2;6, while controlling for manner of articulation (stop, fricative), place of articulation (coronal, labial), syllable number, and bilingual status. Voicing had a significant effect on coda presence ($\beta = -1.11$, $\chi^2(1) = 14.34$, $p = .003$) and accuracy ($\beta = -.93$, $\chi^2(1) = 5.34$, $p = .021$). We then examined the effect of voicing on coda presence and accuracy in Group 3 to 6 while controlling for manner and place of articulation, and bilingual status. We did not include syllable number since it was not found to influence coda production in this age group. Voicing did not have a significant effect on coda presence ($\beta = .18$, $\chi^2(1) = 0.06$, $p = .81$) but it did on accuracy ($\beta = -2.58$, $\chi^2(1) = 52.44$, $p < .001$). Findings on coda presence and accuracy for voiced and voiceless obstruents are presented in Table 8.

Summary: word-final consonants

In sum, manner of articulation was the main factor that influenced word-final coda acquisition. In the younger group, this variable interacted with bilingualism, the main

Table 8. Percent production of word-final obstruent codas organized according to voicing in French-speaking children, aged 2;6 and 3 to 6.

		%coda presence		%coda accuracy	
Obstruents	Mean no. of words	Mean	sd.	Mean	sd.
Group 2;6					
Stop - Voice	9	95.45	10.57	88.76	16.43
Stop + Voice	3	84.98	27.93	69.08	33.78
Fric - Voice	7	92.98	16.84	77.60	23.24
Fric + Voice	5	87.51	21.68	72.16	26.10
Group 3 to 6					
Stop - Voice	8	99.86	1.42	98.86	1.42
Stop + Voice	2	100	0	82.01	27.63
Fric - Voice	8	98.35	5.17	94.64	11.72
Fric + Voice	10	99.26	2.57	68.59	27.27

finding being that target liquid codas were produced less frequently and less accurately by the monolinguals in comparison to the bilinguals. In the older group, all children realized target fricatives less accurately than liquids and nasals, and marginally less well than stops. In addition, target glides were omitted more frequently compared to stops. Our results showed that word length influenced the realization of codas in children, aged 2;6, but no longer in older children. They also showed that age and bilingual status influenced coda accuracy but not coda presence in children aged 3 to 6 years. Finally, focusing on stops and fricatives, we found that voicing influenced the presence and accuracy of codas in the youngest children and the accuracy of codas in the oldest group.

In keeping with the aim of this study, which is to provide normative data on consonant production in French, we provide information on individual consonants in Appendix E. To remind the reader, four codas (k, g, v, ɲ) were not sampled sufficiently in the database to allow comparison with the other consonants. Appendix E shows the pooled results across children (e.g. 49/57 productions of [p] or 85.96% were accurately produced across all children) rather than the mean of each child's production of a given consonant. We considered this a more accurate way to present the data for individual consonants because of the low numbers of productions of certain codas per child. In Group 2;6, the two consonants the most likely to be omitted were the stop /b/ and the liquid /ʁ/ and the codas the least accurately produced were /b, ʃ, ʒ, ʁ/. In Group 3 to 6, the two consonants the most likely to be omitted were /f/ and /j/ and the least accurately produced target codas were /b, d, z, ʒ/. These findings reflect the results of the statistical analyses which show that voiced obstruent codas posed difficulty for children in both age groups. Variation amongst individual consonants within manner classes was not only due to voicing, however. Appendix E shows that Group 2;6's poor results with liquids mainly reflects difficulty with the rhotic /r/ than with the lateral /l/.

Error patterns of word-final consonants

To have a complete understanding of coda production, we also examine the error patterns. Table 9 lists the single most frequent or the two most frequent error patterns for final codas in the two groups of children organized according to individual consonant and manner categories. We focus here on substitutions and not on deletions or epenthesis patterns [7] The numbers in parentheses indicate the number of errors for a given pattern out of the total number of substitution errors. We categorize the errors according to whether they were assimilations (assim) as in crèpe /kʁɛp/ produced as [kwɛk], voicing errors (voice) such as cube /kyb/ produced as [kyp], place of articulation errors (place) such as the alveopalatal fricative /ʃ/ produced as [s] as in fleche /flɛʃ/ [flɛs], and manner of articulation errors (manner) such as the fricative /s/ becoming a stop as in princesse /pʁɛ̃sɛs/ [pʁɛ̃tɛt]. In addition, there were errors in which children produced a complex coda (complex) instead of a simple one as in [fuʁn] for four /fuʁ/; other examples are plante /plɑ̃t/ as [plant] and cube /kyb/ as [kybl]). Finally, in the case of liquids and glides, substitutions errors were varied and difficult to classify; in which case, only an example rather than a classification and example is provided.

[7]Epenthesis was not very frequent but occasionally present in the productions of the 2;6 group (15 examples of which 7 were for /b/ and /d/ codas; [kybə] for cube).

Table 9. Most frequent error patterns (substitutions) for individual codas organized according to manner categories in Group 2;6 and 3 to 6.

	Coda	Group 2;6	Group 3 to 6
Stops	p	assim[a]: crèpe [kwɛk] (3/6)[b]	no errors
	b	voice: cube [kyp] (7/11)	voice: robe [ʁɔp] (18/21)
	t	complex: plante [plant] (8/12)	assim: casquette [kaskɛk] (6/9)
	d	voice: salade [salat] (3/7)	voice: salade [salat] (18/24)
Fricatives	f	voice: girafe [ʒiʁav] (3/7) manner: girafe [ijap] (3/7)	place: carafe [kaʁaʃ] (3/6)
	s	manner: princesse [pʁɛtɛt] (5/12)	place: six [siʃ] (3/6)
	z	voice: chemise [ʃəmis] (7/12)	voice: église [eglis] (85/115)
	ʃ	place: cloche [klɔs] (22/26)	place: flèche [flɛs] (16/18)
	ʒ	place: fromage [somaz] (9/21)	voice: garage [gaʁaʃ] (147/207) place: rouge [ʁuz] (54/207)
Nasals	m	assim: bonhomme [bɔnɔn] (3/3)	place: plume [plyn] (7/7)
	n	assim: banane [banam] (6/9)	no errors
Liquids	l	cheval [ʃəlab] (1/1)	assim: coccinelle [kɔnɛn] (2/4)
	r	fleur [fœj] (4/8)	complex: four [fuʁn] (5/10)
Glide	j	soleil [salɛn] (2/5)	fille [fin] (4/10)

a) assim: assimilation errors; voice: voicing substitutions; place: place of articulation substitutions; manner: manner of articulation substitutions; complex: simple coda replaced by a complex coda.
b) The numbers in parentheses indicate the number of errors for a given pattern out of the total number of substitution errors.

Voiced obstruent and alveopalatal codas were the easiest to classify in terms of errors. Voiced obstruent codas were produced as voiceless and alveopalatal fricatives were produced as alveolar fricatives. Voiceless obstruents displayed varied patterns of which the most frequent was assimilation and place errors. Nasals displayed few errors and were generally substituted by nasals of different places of articulation. Similarly, liquids and glides were characterized by few substitution errors (they were mainly deleted), and these errors were varied and difficult to classify.

Word-medial consonants

In our analyses of medial codas, we contrast /r/ and /s/ codas in word-medial and – final position. We analyse the productions of Group 3 to 6 only since medial codas were not targeted in the younger group. We ran mixed binomial regression models entering the following predictor variables: age (in months), consonant (/r/ or /s/), word position (medial or final), and bilingual status (monolingual, bilingual), as well as random intercepts for participants and items. Word length was not included as factor since it did not influence coda production in Group 3 to 6, at least for word-final position. We did, however, test the interaction between age and word position, and age and consonant since we predicted that developmental effects may influence one word position more than another (e.g. word-medial) and one consonant more than another (e.g., /s/).

The first model examined the effect of these factors on coda presence. Results indicated that consonant ($\beta = -2.49$, $\chi^2(1) = 4.05$, $p = .04$), word position ($\beta = -6.24$, $\chi^2(1) = 27.94$, $p < .001$), and the interaction between age and consonant ($\beta = .055$, $\chi^2(1) = 5.99$, $p = .01$), and age and word position ($\beta = .073$, $\chi^2(1) = 11.79$, $p < .001$) have significant effects. In a second model, we examined the influence of these factors on coda accuracy. Similar results were obtained: consonant ($\beta = -2.53$, $\chi^2(1) = 6.45$, $p = .01$), word position ($\beta = 4.73$, $\chi^2(1) = 22.75$, $p < .001$), and the interaction between age and consonant ($\beta = .038$, $\chi^2(1) = 5.22$,

p = .02) and age and word position (β = .052, $\chi^2(1)$ = 8.97, p = .003) were significant. Bilingual status was not found to influence coda acquisition in these models. Results of the statistical models are provided in Appendix F.

In sum, children obtained higher scores (presence and accuracy) for target /r/ relative to /s/ codas. They obtained higher scores for word-final relative to -medial codas. Their scores for the two consonants and for the two word-positions differed across age, with the main errors occurring at the younger ages. Figure 1 displays the coda accuracy results for/ r/ and /s/ codas across age. As can be observed in Figure 1, children produced word-final /r/ accurately at all ages; they produced medial /r/ and /s/ and final /s/ less accurately at the younger ages with the greatest number of errors occurring for medial /s/.

Error patterns of word-medial codas

In terms of error patterns, medial /r/ was almost always deleted (54 deletions out of a total of 55 error patterns). Medial /s/ was frequently deleted (29/59), but it was also subject to other processes such as substitution by [ʃ] and [f] (e.g. escargot /ɛskaʁgo/ [ɛʃkaʁgo], [ɛfkaʁgo]) or by metathesis (e.g. casserole /kasʁɔl/ [kaʁsɔl]). In addition, there were a number of cases in which the medial /s/ was present but the /s/ sequence was transformed by the addition of a segment (e.g. casserole /kasʁɔl/ [kastʁɔl).

Discussion

This study examined coda production in French-speaking monolingual and bilingual children, aged 2;6 to 6;10 years. Our primary aim was to provide normative information on coda production and our secondary aim was to examine which factors influenced coda development. Our findings showed that French-speaking children, even from a young age,

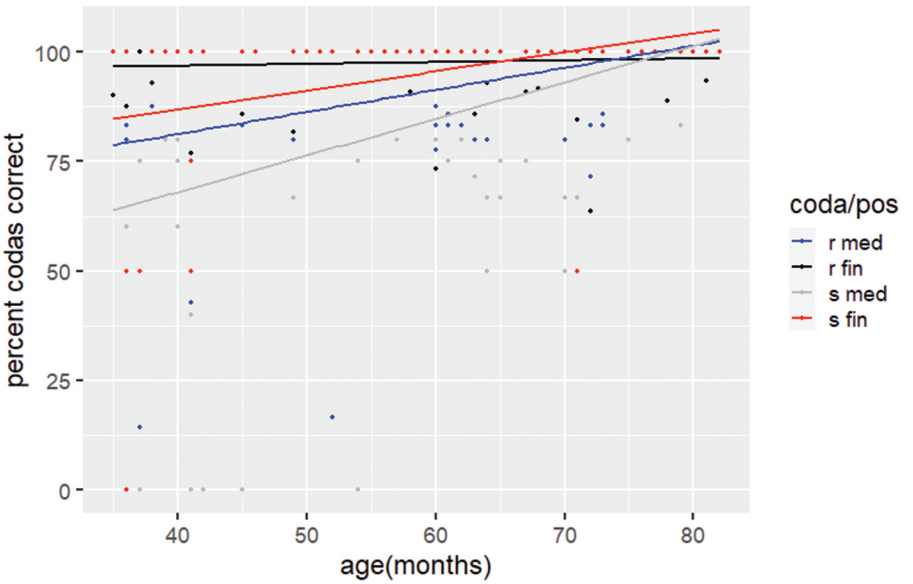

Figure 1. Percent codas correct for medial and final/r/and/s/codas in Group 3 to 6.

have little difficulty producing word-final codas. Factors which influenced coda production included age, manner of articulation, word length, and bilingual status. Word-final codas were also realized with greater percent accuracy than – medial codas. In the following paragraphs, we describe our findings in more detail and consider their relevance for clinical practice.

Word-final coda production

This study showed that French-speaking children have little difficulty producing word-final codas. The high percentages of coda production in French-speaking children are puzzling because codas are infrequent. Spanish has a low percentage of word-final codas, and codas are acquired late in Spanish when compared to other languages (e.g. English and German) in which codas are frequent (Keffala et al., 2018; Lleó et al., 2003). Demuth (2007) already noted that factors apart from frequency need to be recruited to explain the differences between the acquisition of codas in Spanish and French. She suggested that the longer average word length of Spanish, plus the fact that word-final codas may occur in both stressed and unstressed syllables in Spanish may account for the later acquisition of codas in Spanish compared to French. We did not find strong effects of word length on coda production in the current data (only in Group 2;6 for coda presence) making us question whether word length is responsible for the different time line in French and Spanish. We agree, however, that the prosody of French, in which accent is realized in phrase-final position (Dell, 1984), may explain the early acquisition of word-final codas in French versus Spanish. Acoustic analyses of two-syllable words in the current data set reveal that, although the children may not always realize a final pitch accent, they produce final syllables with longer duration than initial syllables, consistent with the acoustic prominence of final position (Kehoe, 2020).

Another factor that may account for the superior results of coda production in French is that codas are more complex in French compared to Spanish. They belong to all places of articulation, whereas in Spanish, they are predominantly coronal. In certain theoretical frameworks, increased complexity of phonological features leads to earlier acquisition (Gierut, 2001; Keffala et al., 2018; Kehoe & Havy, 2019; Tamburelli et al., 2015) which would be consistent with the earlier development of French compared to Spanish codas. Another perspective comes from Rose (2003) who argues that the wider place distribution of codas in French leads children to consistently syllabify word-final consonants as onsets of empty headed syllables; the place restrictions of codas in Spanish leads to variability: some children syllabify word-final consonants as codas whereas others as empty-headed syllables. Taking Rose's (2003) perspective into consideration would require attention to individual acquisition patterns (whether children acquire word-final before -medial codas) according to the child's L1, information which was beyond the scope of the current study. A full understanding of the role of complexity in influencing the different time line of coda acquisition in Spanish and French, thus, awaits further study. Overall, the success French-speaking children have with coda production is similar to what has been reported for Catalan- (Prieto & Bosch-Baliarda, 2006), English- (Bernhardt & Stemberger, 1998), and German-speaking children (Lleó et al., 2003), and different from what has been reported for Spanish- (Lleó et al., 2003) and Japanese-speaking children (Ota, 2003). Future studies should delineate what factors (frequency, prosody, complexity) influence coda production in these languages.

Factors which influence coda acquisition

Our study explored factors which have previously been identified to influence coda development such as age, manner of articulation (and voicing), place of articulation, and word length.

Age. Developmental effects were evident in the production of word-final codas in the age-range 2,6 through to 6;10; however, age effects were tested statistically only in Group 3 to 6. These results indicated that age influenced coda accuracy but not coda presence. Table 10 combines the findings of the current study along with those of Hilaire-Debove and Kehoe (2004), and Gaborieau and Sagaspe (2011) to provide a summary of the influence of age on word-final coda presence and accuracy. All studies tested European French-speaking children using a word naming task.

Hilaire-Debove and Kehoe (2004) provide information on the youngest group of children. They tested children with a mean age of 2;4 and identified three groups of children in terms of coda accuracy: poor (6%), medium (58%) and good (81%). The group with poor results was in the minority (two out of 15 children) whereas the group with good results was in the majority (eight out of the 15). Thus, at 2 years, we observe considerable variability in coda production; however, most of the children could realize codas 90% of the time and be accurate with them 80% of the time, findings consistent with those of children, aged 2;6, in the current study. At 3 years, Gaborieau and Sagaspe (2011) observed higher coda presence (97%) and slightly higher accuracy rates (83%) compared to group 2;6 in our study. Our findings for children aged 2;11 to 3;11 show some improvement in coda presence and accuracy compared to Gaborieau and Sagaspe (2011) results. Finally, children at 4 to 6 years, improve in coda accuracy compared to children at age 3 (this study); however, there were few changes within this period, the mean value being around 93%. Thus, we did not document a period when coda accuracy was 100%.

Manner of articulation. Manner of articulation had a strong effect on coda acquisition. There was not a simple pattern of obstruents being acquired before sonorants as has been noted for coda production in other languages (Demuth et al., 2006; Fikkert, 1994); rather, coda production varied according to different manner classes. Tables 2 and 6 show differences in mean percentages between manner categories with higher results for nasals and stops compared to fricatives, glides and liquids. Our statistical models revealed different effects of manner of articulation according to group. In Group 2;6, liquids posed the greatest difficulty (although mainly for monolinguals), whereas in Group 3 to 6, fricatives did. These

Table 10. Comparison of coda presence and accuracy rates in French-speaking children across different studies.

Study	Age of Children		%Coda presence	%Coda accuracy
Hilaire-Debove & Kehoe (2004)	1;8–2;8	Gp1	13	6
		Gp2	74	58
		Gp3	94	81
Current study	2;6		89	79
Gaborieau & Sagaspe (2011)	3;0		97	83
Current study	2;11–3;11		99	88
	4;0 – 6;10		99	93

findings are consistent with those of Hilaire-Debove and Kehoe (2004), who found manner of articulation differences according to coda ability in two-year-old children. Children who had poorer coda ability had the greatest difficulty with liquids; children who had better ability had the greatest difficulty with fricatives.

The findings based on manner category do not reflect the results for individual consonants, however, in which the least accurate consonants for the youngest group in our study included a stop (i.e., /b, ʃ, ʒ, ʁ/) and the least accurate consonants for the oldest group were voiced obstruents /b, d, z, ʒ/ (see Appendix E). That voicing poses difficulty for coda production was confirmed in our statistical models based on a reduced dataset. In both groups, voicing influenced coda accuracy and, in the younger group, it influenced coda presence. If we put the findings on manner and voicing categories together, we observe the following order of difficulty (for coda accuracy) for children in the 2;6 and 3 to 6 group (see 4).

(4) Percent coda accuracy for Group 2;6 and 3 to 6 ordered in terms of most to the least accurate

a. Group 2;6	b. Group 3 to 6
voiceless stops (89%)	voiceless stops (99%)
nasals (86%)	nasals (99%)
glides (84%)	liquids (98%)
voiceless fricatives (78%)	voiceless fricatives (95%)
liquids (75%)	glides (93%)
voiced fricatives (72%)	voiced stops (82%)
voiced stops (69%)	voiced fricatives (69%)

Voiced obstruents are amongst the codas least well produced in the two age groups, with liquids posing difficulty for the youngest but not the oldest children. This order of development belies a simple sonority/manner of articulation categorization and probably reflects additional factors such as the frequency of individual consonants (Hilaire-Debove & Kehoe, 2004) and articulatory difficulties related to the phonetics of voicing (Smith, 1979), factors which were not examined in the current study.

We also note that a further category could be added to Group 2;6 with the lateral /l/ having high accuracy levels commensurate with nasals and glides, and the rhotic /r/ having low accuracy levels commensurate with the voiceless and voiced fricatives (see Appendix E). No additional category is needed in the older group as /l/ and /r/ were characterized by similar accuracy scores. /r/indeed poses a problem in terms of manner categorization as it functions phonologically as a liquid and phonetically as a fricative (see Rose, 2003). It's phonetic realization as a fricative appears to influence acquisition at the youngest age. We chose to group /l/ and /r/ together to avoid having too many manner categories and ones which consist of a single segment; however, future analyses should take into account the different patterning of /l/ and /r/ word-final codas at the earliest stages of acquisition.

Place of articulation. We were not able to fully evaluate the effects of place of articulation in the current data-set due to the reduced sampling of velar stops /k, g/. In the statistical analyses of the 2;6 but not the older group, place of articulation emerged as significant, although no paired comparison was significantly different in subsequent analyses.

Nevertheless, results of Table 4 indicate that coronal codas were preserved more frequently and were produced more accurately than labial and dorsal /ʁ/ codas, a finding which is consistent with typological predictions (Zamuner et al., 2005) and studies on the acquisition of place sequences (Fikkert & Levelt, 2008).

Word length. Previous research in English (Kirk & Demuth, 2006) and French (Hilaire-Debove & Kehoe, 2004) indicate that word length influences the production of codas. Children produce codas more frequently in short compared to long words, a finding which may relate to production limitations: the articulatory effort required for coda production may be more demanding in a long word, which involves more articulatory coordination than in a short word. We observed a significant word length effect in the youngest group for coda presence but not accuracy. Children aged 2;6 realized codas more often in one- versus two-syllable words; the percentage difference being in the order of 4%. Although this percentage difference may seem small, this effect was obtained while controlling for manner, place and bilingualism, suggesting it was indeed a robust effect. Thus, our findings are consistent with Hilaire-Debove and Kehoe (2004) who tested children younger than the ones in this study.

Bilingual status. Our study also examined coda production separately for monolingual and bilingual children. We observed different effects of bilingualism depending on the group studied. In the youngest group, bilinguals had better coda accuracy results across all manners of articulation except stops (see Table 6); although, in the statistical model, this proved significant for liquids only. The lower scores obtained by the monolinguals for liquids probably reflect difficulty with /r/ which had lower percent accuracy scores compared to /l/ (see Appendix E). We hypothesize that bilinguals might have an advantage for /r/ production compared to monolinguals because they are exposed to different /r/ sounds across their two languages. Several authors have argued that bilingualism may lead to heightened attention to phonemic contrasts and more developed motor control (Grech & Dodd, 2008; Johnson & Lancaster, 1998; Kehoe, 2018; Schmidt & Post, 2015).

In the oldest group, aged 3 to 6, bilinguals had slightly lower accuracy scores than monolinguals, as of the age of 4 years (see Table 6). Bilingual status proved significant in the statistical model, although there was no interaction of bilingualism with manner of articulation. Previous analyses with a similar dataset revealed that the main factor responsible for the poorer result on the part of the bilinguals was their reduced French vocabulary scores, which was a better predictor of coda accuracy than language dominance or language-internal effects such as complexity (Kehoe & Girardier, 2020).

It is curious that we observed two different results for bilingual children: higher scores in the younger and lower scores in the older children. These differences could be due to methodological factors. The youngest group were tested in the university laboratory whereas the oldest group were tested at kindergartens and public schools. There may have been subtle differences between the groups of children at the different test sites which influenced their phonological outcomes. These differences could, however, reflect developmental effects on the bilingual phonological systems. Cross-linguistic interaction may be greatest at younger ages when the phonological system is still developing (hence an advantage for liquids in the bilinguals) but not at the older ages when the phonological

system is largely complete; knowing words in the target language may be important for refining the phonology (hence a general disadvantage for bilinguals).

Word-medial coda production

Our analysis of word-medial codas focused on segments /r/ and /s/ which are some of the most frequent word-medial codas in French (see footnote 2). Our findings confirmed what has been reported before in other languages, namely, that children produce word-medial less well than word-final codas (Borràs-Comes & Prieto, 2013; Kirk & Demuth, 2006). Our statistical models indicated that position effects interacted with age: the youngest children exhibited large differences in percent accuracy between word-medial and – final position (i.e. at age 3: 18% difference for /r/; 21% difference for/s/) whereas the older children exhibited minor differences (i.e. at age 6: 1.5% difference for /r/; 1.5% difference for /s/). We also observed that children experienced more difficulty with medial /s/ relative to /r/.

The poorer results for word-medial in comparison to word-final codas in French are not surprising since word position and stress are confounded: word-medial codas are situated in the unaccented non-final syllable. Nevertheless, Kirk and Demuth (2006) controlled stress and word-position in English and still found an advantage for coda production in word-final position. These authors point out that a word-final coda is followed by silence whereas a word-medial one is followed by another consonant, which has consequences on the perceptual coding, lexical access and subsequent production of words with these types of codas. Word-final codas also require less articulatory coordination than word medial codas which form part of word-internal clusters. Finally, Kirk and Demuth (2006) point to the facilitating role of acoustic prominence in aiding coda production. Children have more time to articulate codas in word-final compared to word-medial syllables due to the longer duration of these syllables.

Error patterns

Analyses of error patterns revealed a variety of substitution patterns for word-final codas, which included examples of consonant harmony (particularly in the 2;6 group), place, manner and voicing substitutions. Voiced codas becoming voiceless was an extremely robust pattern in the data and is consistent with typology of codas in adult languages in which voiced obstruent codas are avoided (Ladefoged & Maddieson, 1996). Another robust pattern in the data was alveopalatal fricatives becoming alveolar; however, this process was not specific to codas, occurring in other positions as well (Aicart-De Falco & Vion, 1987). Word-medial codas were most often deleted or when retained were subject to syllable structure processes (e.g. metathesis, insertion of a segment), which most likely reflect sonority effects on consonant sequences.

Implications for clinical intervention

What are the clinical implications of these findings? This study showed that final consonant deletion is infrequent in typically-developing French-speaking children after the age of 2 to 2;6. Thus, a French-speaking child exhibiting high degrees of final consonant deletion after

this age should be considered at risk for having a speech sound disorder. Our results indicate that young children may have trouble producing liquid codas but after 3 years, they should be largely acquired. In contrast, older children may be inaccurate in their production of voiced obstruent codas through to the age of 7 years. They should not be omitting codas at all, except occasionally for target glides. We observed that three-year olds were highly variable in their production of word-medial codas, often omitting them or producing them inaccurately; however, by 4 years, they had achieved higher performance levels (i.e. 90% or greater). Finally, we documented differences between monolinguals and bilinguals in their production of codas. These differences either interacted with manner classes (Group 2;6) or were of a small magnitude (Group 3 to 6). Thus, we do not recommend separate norms for monolingual versus bilingual children. A three-year-old, who is not producing coda consonants, regardless of whether he/she is monolingual or bilingual should be considered at risk for a speech-sound disorder.

Conclusion

This study examined coda production in two groups of children: children aged 2;6 and children aged between 2;11 and 6;10. Findings showed that several factors influenced coda production including age, manner of articulation (and voicing), word length, word position and bilingualism. By age 3;0, children rarely omitted codas and were highly accurate in their production; although, they continued to make errors on voiced obstruent codas through to 7 years. These findings should aid clinicians when confronted with children who delete or substitute codas to determine whether clinical intervention is necessary. We stress, however, that these results pertain to a word naming task in which words were produced in isolation or in short phrases. Lower percentages of coda presence and accuracy may arise when codas are produced in connected speech.

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Statement of interest

The author reports no conflicts of interest.

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