

IV. Exploring phonotactic and morphonotactic constraints in the acquisition of consonant clusters in L1 French

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1. INTRODUCTION

Consonant clusters are relatively rare in the languages of the world and count as phonologically marked (see e.g. Greenberg 1965; Clements & Keyser 1983; Maddieson 1984; Vennemann 1988; Blevins 1995; Dziubalska-Kołaczyk 2009). Nevertheless, they do figure prominently in a number of languages such as German or Polish. The fact that most of these languages are inflecting-fusional ones and that many of the clusters attested in them occur at morpheme boundaries suggests that morphological factors might be involved in the emergence and first language (L1) acquisition of clusters. In particular, the possibility that clusters may function as boundary signals (cf. already Trubetzkoy 1939) is likely to play a role.

The present study focuses on the time of emergence, position and phonotactic vs. morphonotactic status of consonant clusters (henceforth CC) in the acquisition of L1 French. In order to benefit from the growing number of resources made available by the scientific community, we selected a corpus out of the CHILDES database (MacWhinney 2000), allowing for comparison with L1 acquisition data collected to test the Strong Morphonotactic Hypothesis (SMH) for German (Freiberger 2007, 2014). We then analysed longitudinal data from four children aged 1;6 to 3;0 collected in spontaneous speech interactions between a parent and the target child with a generalized linear mixed model investigating the role of the factors age, position and phonotactic (PH) vs. morphonotactic (MPH) status on the successful pronunciation of the different CCs.

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2. CONSONANT CLUSTERS IN FIRST LANGUAGE ACQUISITION

2.1. PHONOTACTICS AND CONSONANT CLUSTERS

A number of studies have investigated the role of phonotactics in the acquisition of the L1. It is generally assumed that phonotactics provide cues allowing the child to identify word boundaries in speech, hence conferring a key role to phonotactics in word segmentation. This is confirmed by growing evidence about how the acquisition of phonotactics bootstraps the acquisition of lexicon and grammar (cf. Boll-Avetisyan 2012). Moreover, phonotactics also play a role in adult language processing: for instance, McQueen (1998) showed that adults recognize words more rapidly when the junction between two words forms a phoneme cluster that does not typically occur within words. Such findings draw attention to the role of CCs and their significance in phonotactics since their nature and distribution varies a lot across languages.

The production of CCs has been shown to be particularly difficult in L1 acquisition, in accordance with the idea that more marked structures (Trubetzkoy 1939) will be more difficult to acquire than less marked ones. However, it has also been shown that the ease of acquisition of CCs is not homogenous and depends on a number of parameters such as syllable structure, position, frequency, morphology and input factors (e.g. Demuth & McCullough 2009), which also differ across languages. In the same vein, Levelt, Schiller and Levelt (2000) have shown that the order of acquisition of syllable structures “closely matched the frequency with which those syllable structures occurred in child-directed speech” (cited by Demuth & McCullough 2009: 427).

Structural aspects of phonotactics have been comprehensively described in the Beats-and-Binding model of Dziubalska-Kołaczyk (2002), providing a scale of preference for markedness based on overall sonority as composed of sonority, place of articulation and voicing. Studies by Demuth and collaborators on L1 acquisition also take into account sonority (e.g. Demuth & McCullough 2009). In addition, it has been suggested that syllable-initial consonants are less marked than syllable-final consonants and hence easier to acquire, the former also being present in a larger number of languages. The same should hold for CCs in an initial position, which should be easier to acquire than CCs in a final position. However, for analytic languages such as English, the contrary seems to be true, which has been explained through frequency and syllable structure effects, among other things (see Demuth 2007; or Demuth & McCullough 2009, for reviews). Data for Dutch (where word-initial and word-final

clusters are about equally frequent) suggest that some children produce clusters more easily in the initial position and others in the final position.

These data suggest a strong link between the acquisitional process and the structure of the target language. Demuth and McCullough (2009) have challenged these predictions with respect to French, based on the idea that analyses of child-directed speech show that around 70% of CCs are in the word-initial position, predicting a frequency advantage for word-initial clusters. This hypothesis is investigated with the analysis of the speech production of two children (Tim and Marie from the Lyon Corpus recorded by Demuth & Tremblay 2008) recorded repeatedly between ages 1;5 and 3;0. The results show higher accuracy in the production of word-initial CCs than word-final CCs as predicted, and this independently of syllable structure factors such as sonority. The study furthermore showed that word-medial CCs were produced with roughly the same accuracy as word-initial CCs in French.

2.2. MORPHONOTACTICS AND CONSONANT CLUSTERS

Apart from frequency and structurally based factors, morphological structure has also been supposed to play a role in the acquisition of CCs. For example, Kirk and Demuth (2005) examined the production of CCs in an elicitation task in English-speaking two-year-olds and found that the children were more accurate in producing word-final clusters consisting of obstruent +/s/ compared to word-initial clusters (e.g. cups vs. spoon) and, most interestingly, to final clusters with the same but reversed segmental content (e.g. cups vs. wasp). The authors explain these results through both input-related and morphological factors: obstruent +/s/ clusters are more frequent, but most importantly (and probably linked to the first factor), they involve an inflectional (and very productive) morpheme. This could lead to a morphological advantage for final clusters, which, in turn, may help children acquiring languages such as English to focus very early on complexity at the end of the words. Furthermore, morphological effects appear very early in language perception and production. Numerous studies suggest that infants start perceiving functional morphemes at an early age. They distinguish forms of function words (free morphemes) from content words and decode specific function words during the first year of life (e.g. Shi & Werker 2003; Shi, Werker & Cutler 2006; Shi, Werker & Morgan 1999).

A recent study conducted by Marquis and Shi (2012) provided the first empirical evidence that French-learning 11-month-olds can use the

encoded bound morphemes for interpreting the internal units of newly encountered words. They demonstrated that infants analyse the word-internal morphology during their first year of life before learning word meaning, and that the decoding of a bound functional morpheme depends on the morpheme frequency. This finding suggests that rudimentary representations of morphological alternations emerge very early in the long-term memory of infants. Finally, in an application of the Beats-and-Binding model to L1 acquisition, Zydorowicz (2007, 2009) has shown that Polish-speaking children reduce morphonotactic clusters less frequently than phonotactic ones, similarly to what has been shown for Lithuanian and English (Kamandulytė 2006; Kirk & Demuth 2005).

Despite such promising results, investigations of how morphotactics facilitate the acquisition of phonotactics in children are still rare. However, Dressler and Dziubalska-Kołaczyk (2006) and Dressler, Dziubalska-Kołaczyk and Pestal (2010) have elaborated a model of morphonotactics and its correspondence to phonotactics that has been tested in preliminary studies on L1 acquisition of German (Freiberger 2014). The Strong Morphonotactic Hypothesis (SMH) issued within this framework assumes that typically developing children should acquire morphonotactic clusters earlier than comparable purely phonotactic ones, because morphonotactic clusters are likely to be expressed more consistently in the input to which the children are exposed. Moreover, their segmental constituents will also occur independently of each other in phonologically less marked configurations. The investigation of morphonotactic clusters acquired during different acquisitional phases of productive morphology (cf. Bittner, Dressler & Kilani-Schoch 2003) should allow us to establish which of the two factors plays a more important role. The framework also assumes that morphonotactic clusters with many phonotactic counterparts lack a morphological signalling function. Moreover, they may often be affected by the same repair mechanisms as parallel phonotactic clusters and expressed less faithfully in the adult speech input than morphonotactic clusters with few or no phonotactic counterparts. Therefore, they also ought to be acquired less easily and during later phases. Nevertheless, adult-like production of morphonotactic clusters may precede (in terms of the first emergence or frequency of occurrence) the production of homophonous purely phonotactic clusters.

Furthermore, phonologically more marked clusters should be acquired later than less marked ones (independently of whether they are phonotactic or morphonotactic). Still, it needs to be investigated how the acquisition of morphonotactic clusters is affected by the absence or pres-

ence and also the frequency of parallel phonotactic ones. The framework also stresses that the measurement of markedness should differentiate between different positions in the word and give much consideration to ease of perception (such as the Net Auditory Distance among segments, as proposed by Dziubalska-Kołaczyk 2009).

These assumptions have been investigated by Freiberger (2014) through the analysis of a longitudinal corpus of spontaneous speech data from 3 typically developing monolingual children acquiring German as an L1 in Austria that was analysed with respect to the interaction of phonotactic and morphotactic factors. For each child, the researcher selected 30 minutes of recordings per month between age 1;6 and 3;0³. Three developmental phases were distinguished during this period. The data were transcribed according to CHILDES norms, all spontaneously produced clusters were extracted, and correctly vs. incorrectly pronounced clusters were analysed with respect to the number of consonants, position, morphonotactic vs. phonotactic status and number of morphological boundaries. The results showed the expected progression in accuracy with age and that the children had more difficulties with initial than with medial and final clusters (similarly to what has been shown for English). While morphonotactic clusters did not involve additional difficulties due to their complexity, there was no interaction between morphological and phonological factors as expected.

Given the specificities in the acquisition of morphonotactic CCs to be expected in different languages varying with respect to inflectional patterns and phonological typology, the present study seeks to complement existing data on the acquisition of CCs in Polish, German, English and Lithuanian with data from French that, as a Romance language, can be expected to show a different acquisitional path. While some data exist on phonotactic factors, previous studies on CC acquisition in French have not taken morphological factors into account.

3. METHODOLOGY

The aim of the present study was to explore the acquisition of CCs by L1 French children, their time of emergence and speed of acquisition, as well as to scrutinize aspects of the SMH (Dressler & Dziubalska-Kołaczyk 2006) in L1 French acquisition. In order to provide data that

³ One of the children was recorded from age 1;3, allowing the author to take into account a fourth developmental stage, T0, for this child.

can be compared to other related studies within this framework, the methodology chosen is based on a replication of Freiberger's (2014) analysis of a corpus with data from 3 children aged 1;6 to 3;0.

3.1. CORPUS SELECTION

An increasing number of resources on L1 acquisition have been made available to the scientific community in recent years. For the present study, we referred to the CHILDES database (MacWhinney 2000) and selected a corpus with a comparable recording process to the methodology used by Freiberger (2014) in order to test the SMH in L1 German acquisition. The criteria we used were the recording of spontaneous speech interactions between a parent and the target child, an age of onset of 1;6 and regular recordings up to 3;0. The corpus recorded by Demuth and Tremblay (2008) (hereafter 'Lyon Corpus') meets these requirements: four children were, on average, recorded bimonthly (Anaïs, Marie, Nathan and Theotime) from an age onset of 1;0 to the age of 3;0 (4;0 for Marie) and the children's utterances have been orthographically and phonetically transcribed in CHAT format (MacWhinney 2000). The data of one of the children (Marie) had already been analysed with respect to the acquisition of CCs (together with data from Tim in Demuth & McCullough 2009). A further advantage of the Lyon Corpus is that data for child-directed speech are available from the mothers of the children.

3.2. METHODOLOGY AND CHARACTERISTICS OF THE CORPUS

The data analysed here are summarized in Table 1. We have analysed 18 recordings per child for Anaïs, Marie and Theotime and 20 recordings for Nathan. The table shows that the number of word tokens is highly variable from one child to another – as can be expected in this age group – ranging from 6,396 tokens (Nathan) to 22,729 tokens (Anaïs). First of all, we analysed the orthographic transcription of the corpus. To start with, we performed a frequency count of each lexical item transcribed from these recordings and sorted all words containing CCs with the help of the `FREQ` command in `CLAN` (`freq*.cha +t*CHI`) followed by manual extraction of the targets. The following tokens were excluded from this analysis: some complex lexical units (*parce que* 'because')⁴, proper

⁴ In what follows, we provide English translations for the French lexical units, but not for proper names and interjections or onomatopoeia.

names (*Amtaro*) and onomatopoeia (*vroum*). The analysis shows that infant speech in French involves an interesting, albeit also variable proportion of words containing CCs ranging from 4.4% for Anaïs to 10.6% for Theotime).

Table 1. Number of recordings and tokens per child, percentages of CC tokens in the corpus

Child	Recordings (age)	Total number of word tokens	CC (% of total)
Anaïs	18 (1;0–3;0)	22,729	1023 (4.50%)
Marie	18 (1;0–4;0)	19,496	1642 (8.42%)
Nathan	20 (1;0–3;0)	6,396	464 (7.25%)
Theotime	18 (1;0–3;0)	20,150	2140 (10.62%)

Further analysis of the words produced by two of the children (Marie and Nathan) demonstrates the variety of CCs found in the speech of the children. Table 2 presents a summary of the cluster combinations according to consonant type of the first and the second consonant. Unsurprisingly, the table clearly shows that combinations of plosives and liquids are most frequent in infant speech (see also Demuth & McCullough 2009). The data also provide evidence for the presence of some more complex clusters involving three or four consonants (see Table 3).

Table 2. Variety of CCs in Marie and Nathan's recordings

C2	Fricative	Plosive	Liquid
C1			
Fricative	/sf/	/ʃk/ /sk/ /sp/ /st/	/fl/ /fr/ /zl/ /vr/
Plosive	/ks/ /ps/ /tʃ/	/gb/ /kt/ /mt/ /pt/	/bl/ /br/ /dr/ /gl/ /gr/ / kl/ /kr/ /pl/ /pr/ /tr/
Liquid	/ls/ /rs/ /rʃ/ /rz/ / rʒ/ /rv/	/ld/ /lk/ /lm/ /ln/ /lt/ /rb/ /rd/ / rg/ /rk/ /rm/ /rn/ /rp/ /rt/	/rl/

Table 3. CCs with 3 or more consonant sounds in Marie's and Nathan's recordings

3+ CCs
/kspl/ /kspr/ /lkr/ /rbr/ /rkl/ /rsk/ /str/

We also analysed the number of CCs for different developmental stages, similarly to the analyses by Freiburger (2014). The data summarized in Table 4 show a clear progression of the number of CCs with age for each

child. However, bear in mind that these data were obtained with the orthographical tier and remain hypothetical with respect to the actual production of the CCs. As such, they mainly demonstrate the diversification and complexification of the lexicon in each child.

Table 4. Number of CCs in the word tokens per child for each age group

Child	1;6–1;8	1;9–1;11	2;0–2;2	2;3–2;5	2;6–2;8	2;9–2;11	3;0–3;2
Anaïs	12	11	78	164	271	221	268
Marie	12	82	200	161	290	525	376
Nathan	6	31	20	126	69	130	82
Théo	51	213	163	399	239	648	428

Qualitative analysis of the words (see Tables I and II in appendix) shows that the first words containing CCs produced by French L1 children are from various categories with an important proportion of nouns (e.g. *nounours* ‘teddy’, *veste* ‘jacket’, *écharpe* ‘scarf’, *fleur* ‘flower’, *fraise* ‘strawberry’) and interjections/onomatopoeia (e.g. *bravo*, *oups*, *vroum*, *gling*, *clac*, *crac*) followed by adverbs or adverbial locutions (e.g. *s’il-te-plaît* ‘please’, *après* ‘after’, *autre* ‘other’, *plein* ‘lots’, *trop* ‘too much’) and verbs (e.g. *regarde* ‘look’, *prend* ‘take’, *parti* ‘gone’, *marche* ‘walk’, *ferme* ‘close’), mostly in infinitive or participle constructions.

We then sorted words containing CCs that were classified as either phonotactic or morphonotactic in the productions of the four children (see Table 5). This was achieved with the *FREQ* command provided by *CLAN*. In addition, manual extraction of our targets allowed us to establish the CC’s frequency in French and their phonemic variety in infant speech. Then, the CCs presented in Tables 2 and 3 were set up as targets we systematically searched for within a subset of the Lyon Corpus. This subset is composed of around 20 hours of recording for each child and balanced across different time frames. Within this subcorpus, we compared for each target token the expected phonological form and the child’s actual pronunciation. Through *KWAL* commands followed by manual extraction, we sorted 5,276 occurrences which were categorized according to the following criteria: child, age, gender, CC group (Table 2 headers), CC (Table 2 contents), CC position (initial, medial, final), PH vs. MPH (phonotactic vs. morphonotactic cluster), grammatical class, lexical form, number of syllables, phonetic realization, CC realization (0 = error; 1 = success), and the type of CC error (reduction, substitution, omission, repetition, epenthesis, shifted cluster or mixed sounds).

Table 5. Total number of phonotactic (PH) and morphonotactic (MPH) clusters in each position for the four children

	initial	medial	final	Total
MPH		289	721	1,010
PH	1,932	1,297	1,030	4,259
Total	1,932	1,586	1,751	5,269

Table 5 shows that there are more than four times as many phonotactic clusters ($N = 4,259$) than morphonotactic clusters ($N = 1,010$) in the recordings. While PH clusters appear in all positions and even slightly more in the word-initial position, MPH clusters mostly appear in the final position and to a lesser extent in the middle of words, but not at all in the word-initial position. The latter finding is not surprising since word-initial MPH clusters are non-existent in French and consequently absent from child-directed speech (Demuth & McCullough 2009).

Table 6. Distribution of the different types of MPH clusters in word-medial and word-final position

Cluster MPH	Example	Position		Total MPH
		medial	final	
Dr	<i>prendre</i> ‘take’		7	7
Rd	<i>regarde</i> ⁵ ‘look’	58	541	599
Rk	<i>pourquoi</i> ‘why’	162		162
Rm	<i>dormi</i> ‘slept’	14	1	15
Rt	<i>parti</i> ‘gone’	52	8	60
Sf	<i>transforme</i> ‘transform’	3		3
Tr	<i>mettre</i> ‘put’		164	164
Total		289	721	1,010

Table 6 shows the number of tokens and distribution of the different MPH clusters in the corpus. It is obvious from the data that some of the clusters are very rare and appear in only one specific word. For example,

⁵ The data concerning these items have, however, to be treated with caution. First, the morphotactic status of the cluster is questionable since the different forms of the verb *regarder* ‘to look’ are principally opposed to the noun *regard* ‘gaze’ (rare in child language!), and the noun is derived from the verb, and not the other way around (Dressler, personal communication). Additionally, as we will see later, this cluster is very frequently reduced through omission of the liquid by the children, but also in child-directed speech (Demuth & McCullough 2009).

‘sf’ is limited to the word *transforme* ‘transform’ and only appears in this configuration in a word-medial position. Other clusters show high overall frequency, but again, they appear in only one very frequent token (*pour-quoi* ‘why’, *regarde* ‘look’).

We then proceeded to the analysis of the phonological tier allowing us to establish the proportion of CCs correctly produced. Table 7 recapitulates the percentage of correctly produced clusters for each child in the different developmental stages. The high variability across the children is striking. While two of the children (Marie and Theotime) reach more than 80% correct performances by age 3, the proportion is only 40% for Nathan (and not yet stable), and it does not exceed 10% for Anaïs, for whom no real progression is evident over the recording periods. Furthermore, it cannot be excluded that the actual production of CCs is related to the use of words containing CCs, the two children obtaining the highest mastery of CCs also being those who produce the most words containing them (see Table 4). However, it also has to be noted that Anaïs, who shows clear difficulties with CCs, seems to be rather talkative, as indicated by the number of tokens produced (see Table 1).

Table 7. Percentage of correctly produced consonant clusters per child and per age group

Child	1;6–1;8	1;9–1;11	2;0–2;2	2;3–2;5	2;6–2;8	2;9–2;11	3;0–3;2
Anaïs	0	9.09	2.56	0.61	9.96	4.98	10.07
Marie	0	10.98	9.00	34.78	57.24	81.14	80.05
Nathan	0	3.23	10.00	3.17	14.49	14.62	40.24
Theotime	7.84	41.31	61.35	70.68	81.97	87.96	84.11

We then applied a generalized linear mixed model investigating the role of the following factors: age, position and PH vs. MPH status on the successful pronunciation of the different CCs. The results of this analysis are presented in the next section.

3.3. STATISTICAL EXPLORATION OF THE FACTORS FAVOURING SUCCESSFUL PRONUNCIATION OF CCs

For the statistical exploration, a generalized linear mixed model was chosen because our data consider a binary nominal variable (is a CC produced correctly or not) in relationship with a list of factors, some of these being random (e.g. the child’s proficiency or the difficulty in pronouncing a CC) and others considered as independent variables (e.g. PH/MPH status).

With such a model, the slope of the logit is modelled over time (that is, the fixed effect on the probability that a CC is correctly produced), depending on the position of the CC, its PH or MPH status, the number of syllables in the word, and so on. We have defined two types of random effects:

- the children (who are more or less performant [1])
- the CC types (which are more or less difficult to produce and more or less frequent [2])

Model 0 inspected the evolution of performance depending on the age of the children. The 4 children and all 10 CC classes (e.g. *liquid+plosive* or *plosive+obstruent*) were taken as random effects in the model. The results show that with growing age, the probability of a ‘correct’ answer increases significantly ($\beta = 0.63$, $p = 0.001$), as can be expected with typically developing children. Figure 1 represents the probability slope that should be expected for any child, following Model 0’s data.

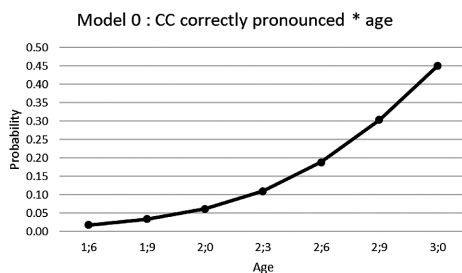


Figure 1. Percentage of consonant clusters correctly pronounced per age group (Model 0)

For Model 1, we added the morphonotactic status of the CC (PH vs. MPH) to the factor age and took into account the possible interactions between these factors. As for Model 0, an increase in age results in an increase of the probability that a CC is correctly produced ($\beta = 0.71$, $p = 0.001$). The model also suggests that the MPH status over all age groups had a positive effect on the pronunciation of CCs ($\beta = 0.72$, $p = 0.02$). However, the negative interaction between the factor age and MPH status tempers this result ($\beta = -0.37$, $p = 0.001$). To refine these first results, and as MPH CCs are not spread evenly across positions in the word, the following statistical models take into account the position of the CC in the word.

Model 2 considered the CCs located in the word-initial position as well as the age groups. As CCs in this position cannot have MPH status,

the latter factor was excluded from the model. Model 2 reports a positive effect of increasing age ($\beta = 0.59, p = 0.001$) and the initial position of the CC ($\beta = 0.75, p < 0.01$) on the success of pronunciation of a CC. The interaction between these two factors also has a positive, albeit slight, effect ($\beta = 0.15, p = 0.001$).

Model 3 investigated CCs located in the word-medial position, age groups, and the CC's MPH status. Again, rising age results in an increase in the probability that a CC will be pronounced correctly ($\beta = 0.63, p = 0.001$). Nonetheless, when considered alone, the MPH status of the CC ($\beta = -1.39, p = 0.001$) and the medial position of CCs ($\beta = -0.73, p < 0.01$) seems to decrease the chance that a CC will be produced correctly. If we now consider the interactions in Model 3, there is a positive interaction between MPH status*medial position ($\beta = 1.76, p = 0.001$) with respect to correct pronunciation of the CC, while a less pronounced positive effect is observed for the age*CC's medial position interaction ($\beta = 0.20, p < 0.01$).

Finally, Model 4 focused on the CCs in the word-final position, while also taking into account age and MPH status. The age factor remained, once again, the major effect ($\beta = 0.80, p = 0.001$) in the model. When isolated, factors such as the final position and MPH status had no significant effect in this model. However, the interactions age*final position ($\beta = -0.35, p = 0.001$) and MPH status*final position ($\beta = -0.54, p = < 0.05$) showed a moderate negative effect on the probability that a CC will be produced correctly.

To summarize our results, the statistical analysis showed that the factor age was the most important influence on the children's output, as can be expected from typically developing children. Concerning the CC's position in the word, French children tend overall to a left-side preference in the development of the pronunciation of CCs, with word-initial CCs tending to be produced correctly at an earlier age. As for the CC's MPH status, our models observed that only MPH clusters in a medial position (and probably specifically for the latest age group considered here) had positive effects on the success of pronunciation of clusters. That being said, it must be kept in mind that these results may be influenced by several factors inherent to our corpus:

- MPH clusters are relatively scarce in French words, and even more so in children's spontaneous speech corpora;
- MPH clusters occur only in a limited number of words, but these are likely to be very frequent French words, such as *pourquoi*

‘why’ with a cluster in the medial position, or *regarde*⁶ ‘look’, in imperative mode, with a cluster in the final position. If *regarde* is used as a deictic from very early on (543 tokens, from age 1;6 in the corpus) by both children and caregivers, *pourquoi* (162 tokens, from age 2;0 in the corpus) emerges later in the child lexicon, i.e. at a more advanced developmental stage.

Nevertheless, the results also showed that there is a lot of variation among the children, which is why the next section seeks to explore further the individual developmental trajectories.

3.4. EXPLORATION OF THE INDIVIDUAL DEVELOPMENTAL TRAJECTORIES

The developmental trajectories for each of the four children were explored with reference to the type of the given responses, first for all CCs and then specifically for MPH clusters. The results for overall CC production (see Figure 2) illustrate the inter-individual differences: while two of the children (Anaïs and Nathan) produce hardly any correct clusters during the entire period of investigation (1;6–3;0), the other two (Marie and Theotime) show a steady increase in correct production from age 2;0 (Marie) and age 1;6 (Theotime) respectively. Additionally, error patterns are also interesting and demonstrate a specific trajectory for each child. While substitutions are rare in the production of all four, the children differ considerably with respect to the amount and distribution of the other error types. Theotime is very performant from the beginning, and omissions of CCs are rare in his speech even at the first recording, and remain close to zero thereafter. By preference he uses reductions of CCs, but even these are exceeded by correct productions from as early as around age 1;8. Both Nathan and Marie start with 100% omissions at age 1;6, but these are caught up by reductions at around age 1;8 for Marie and 2;4 for Nathan. Anaïs, who shows the most severe difficulties with CCs, has a quite different distribution of these two error types: from the beginning, she produces more reductions than omissions, and despite a lot of variation in the different recordings, this does not change substantially over the period investigated.

We then looked specifically at the distribution of these error types and the correct productions of CCs in MPH clusters only (see Figure 3). Anaïs’ CC productions remain close to zero during the whole investiga-

⁶ But see our reservations about the MPH status of the final cluster in *regarde* in note 3 (section 2.2).

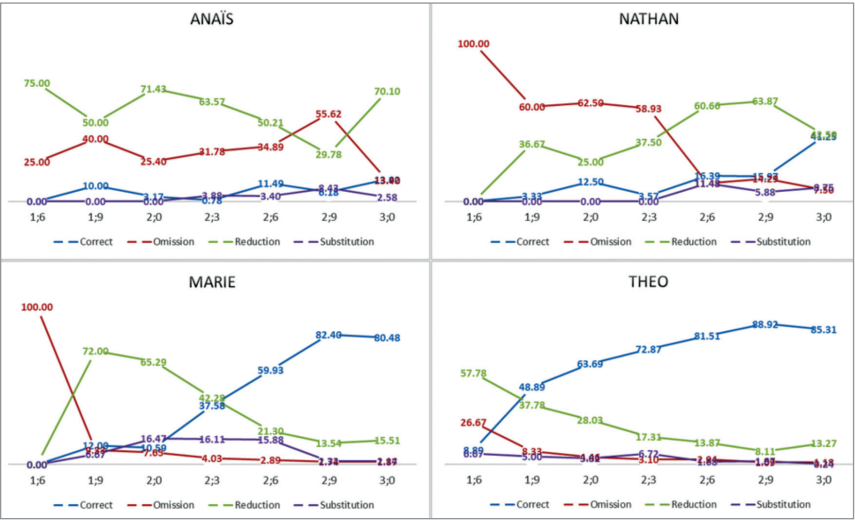


Figure 2. Percentage of occurrence of each type of CC event coded in the corpus for each child/age group. Correctly produced CC (blue), CC omission (red), CC reduction (green), CC substitution (purple).

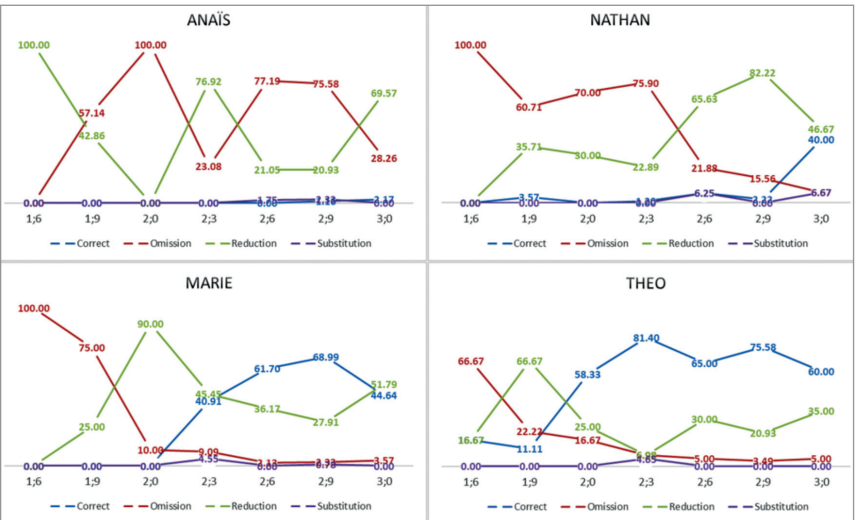


Figure 3. Percentage of occurrence of each type of event coded in the corpus for MPH clusters only * child * age group. Correctly produced CC (blue), CC omission (red), CC reduction (green), CC substitution (purple)

tion period, while errors seem to be distributed randomly between reductions and omissions. In Nathan's speech, correctly pronounced MPH CCs appear only at the end of the period, from age 2;9 onwards, and reductions start to exceed omissions from around age 2;5 onwards. Marie shows a similar pattern, but much earlier: correct productions appear at age 2;0 and the number of reductions exceed the omissions from around age 1;10. For Theotime the trajectory here is more similar to the pattern shown by Nathan and Marie, but even earlier than Marie and with higher success rates. Despite the high variability across children, these data suggest that there is an overall developmental pattern with the number of omissions decreasing while the number of reductions increases across the age groups.

4. DISCUSSION

The results of our data analysis are in line with the other studies on the acquisition of consonant clusters in French, showing that all these clusters are subject to different types of modifications (namely reduction to the least sonorous segment, gliding, insertion of schwa, etc.) before they are produced in a target-like manner. This has been documented, for example, in the study conducted by Andreassen (2013) on 13 monolingual children aged 2;2–3;2 years. The data are also consistent with the studies on CC acquisition in general (for a review, see McLeod, van Doorn & Reed 2001) showing that CCs emerge very progressively around age 2 (e.g. French 1989; Lléo & Prinz 1996, for Spanish and German). Overall, the studies on CC acquisition suggest that production of CCs starts around age 2, but, independently of the target language, their production is rarely correct at that age. Additionally, the age of mastery seems to be highly variable across children, as also documented by the data from the four children we considered in this study showing considerable variation in the correct CC productions of, for instance, Anaïs (10.07% correct at age 3;0–3;2) and Theotime (84.11% correct at the same age). With regard to American English, Shriberg and Kwiatkowski (1980) observed 90% correct at age 4, while Smit et al. (1990), on the contrary, report that only few productions were correct at age 4. In their sample the majority of CCs seemed to be mastered at age 6 or 7, though some difficulties persisted even up to age 8 or 9.

Among the factors generally found to influence the age of mastery of pronunciation are the position and structure of the cluster. Yet the observations made with respect to these factors are still inconsistent. For exam-

ple, McLeod and colleagues, in an extensive literature review on CC acquisition, state that “In languages other than English, word-final CC have been reported to be acquired before word-initial clusters” (McLeod et al. 2001: 101). However, as regards French, word-initial clusters tend to be produced earlier than word-final clusters (see Demuth & McCullough 2009; Kirk & Demuth 2005). While it is also acknowledged that the position no longer matters in older children, such inconsistencies between studies need to be elucidated.

Additionally, McLeod et al. (2001) suggest that clusters involving plosive+liquid are easier to acquire than clusters involving fricative+liquid. This is in line with what has been observed by Demuth and colleagues (Demuth & McCullough 2009; Demuth & Tremblay 2008) for the acquisition of CCs in French. However, there are also a number of other, less investigated factors that are likely to play a role in language-specific acquisition trajectories: the syllable structure, foot structure, frequency (e.g. Kehoe et al. 2008), saliency (Baroni 2014) and the primary and secondary status of the cluster (Andreassen 2013). For instance, there is a strong tendency for French towards monosyllabism resulting in a reduced number of morphemes per words and hence in fewer morphological boundaries and reduced morphonotactics.

Concerning our main research questions, the findings of the present study suggest that there are differences in the processing of MPH and PH clusters in the acquisition of L1 French. These are, however, modulated by the fact the MPH clusters mainly appear in the word-final position in French (and to a lesser extent in a medial position), a position that seems, for other reasons, to be less favourable in early acquisition. The observations we made are consistent with the predictions of the SMH in respect of the phonological and morphological characteristics of French (Dressler & Dziubalska-Kolaczyk 2006). From a phonological point of view, French is a largely vocalic language and, as such, has only a limited number of consonant clusters. On the morphological side, French is one of the weakest inflecting languages among the fusional languages (at least as far as oral French is concerned). Consequently, and as predicted by morphonotactics, the number of MPH clusters is rather low, at least in the vocabulary of the age groups investigated in the present study, and results have to be treated with caution. In order to counterbalance frequency effects, it might be interesting to compare data from younger children acquiring languages with many MPH clusters with older children acquiring languages with few MPH clusters.

Another issue that needs to be discussed is the actual presence of the investigated clusters in child-directed speech to which these children are exposed. Recent studies on speech directed to French infants suggest that French parents tend to reduce omission of schwa when addressing their young children (e.g. Andreassen 2011; Liégeois, Saddour & Chabanal 2015). Reduced omission of liquids in consonant clusters has also been reported for child-directed speech in connection with one of the children investigated in the present study in respect of word-initial clusters, where parents tend to produce more complete clusters when addressing their young children compared to their usage in adult-directed speech (Demuth & McCullough 2009). However, things seem to be more variable with regard to word-final clusters: while the results of the same study showed very low omission rates for /R/-plosive clusters (e.g. *barbe* ‘beard’ in our corpus – with the exception of *regarde* ‘look’, one of the most frequent productions in our corpus where omission rates are fairly high), omission rates were high for final plosive-/R/ clusters (75% for Marie’s mother, e.g. *autre* ‘other’). This suggests that the advantage observed for the acquisition of word-initial CCs is not only due to overall frequency but also to the fact that word-final clusters are often phonetically reduced in the input (see Demuth & McCullough 2009, for more details).

5. CONCLUSION AND PERSPECTIVES

Based on a longitudinal corpus analysis of natural data from four children, the present study provides preliminary data on the scope of the SMH (Dressler & Dziubalska-Kołaczyk 2006) as regards French. In accordance with the predictions of the SMH, our data show that the morphonological status of a CC does not *per se* facilitate its acquisition, which is largely modulated through other factors such as frequency and position in the word, at least in the initial developmental stages investigated in the present study. However, of course, the present investigation has only permitted a preliminary exploration of the issue of the interaction of phonological and morphological aspects in the development of CCs in French. An extension of the study to later developmental stages in older children, allowing us to weight the influence of frequency, is clearly one of the primary perspectives arising from the present investigation. It would also be interesting to look more closely into the processing cost with regard to the processing of inflected forms without clusters and to inspect error patterns related to PH/MPH status of CCs.

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APPENDIX

Table I. Types of clusters starting with fricatives or plosives and their representations per position, their PH or MPH status, number and proportion

Cluster Group	FRI+FRI	FRI+PLO	FRI+LIQ	PLO+FRI	PLO+LIQ			PLO+PLO
Cluster	sf	sk	fl	ks	bl	gr	pr	gb
Exemple	transformé	casquette	fleur	coccinelle	blanc	gros	après	rugby
Position(s)	n_y_n	y_y_y	y_y_y	n_y_n	y_y_y	y_y_y	y_y_y	n_y_n
PH_MPH	n_y	y_n	y_n	y_n	y_n	y_n	y_n	y_n
Count (%)	3 (0.06)	102 (1.93)	46 (0.87)	24 (0.45)	196 (3.71)	364 (6.9)	271 (5.14)	1 (0.02)
Cluster		sp	fr	tf	br	kl	tr	kt
Exemple		aspirateur	fraîse	atchoum	zèbre	clé	autre	docteur
Position(s)		y_y_n	y_y_y	n_y_y	y_y_y	y_y_y	y_y_y	n_y_y
PH_MPH		y_n	y_n	y_n	y_n	y_n	y_y	y_n
Count (%)		34 (0.64)	88 (1.67)	8 (0.15)	127 (2.41)	56 (1.06)	1135 (21.51)	17 (0.32)
Cluster		st	zl	gz	dr	kr		pt
Exemple		veste	puzzle	exemple	chaudron	crocodile		hélicoptère
Position(s)		y_y_y	n_n_y	n_y_n	y_y_y	y_y_y		n_y_n
PH_MPH		y_n	y_n	y_n	y_y	y_n		y_n
Count (%)		51 (0.97)	15 (0.28)	1 (0.02)	86 (1.63)	295 (5.59)		20 (0.8)
Cluster			vr		gl	pl		
Exemple			vroum		igloo	plein		
Position(s)			y_y_y		y_y_y	y_y_y		
PH_MPH			y_n		y_n	y_n		
Count (%)			109 (2.07)		47 (0.89)	385 (7.3)		

Table II. Types of clusters starting with liquids and their representations per position, their PH or MPH status, number and proportion

Cluster Group		LIQ+FRI		LIQ+PLO				LIQ+LIQ		3+	
Cluster		rs	rz	lk	rb	rk	rp	rl	kspl	rbr	
Exemple		moreau	quatorze	quelqu'un	barbe	pourquoi	écharpe	parle	expliquent	arbre	
Position(s)		n_y_y	n_y_y	n_y_y	n_y_y	n_y_y	n_y_y	n_y_y	n_y_n	n_y_y	
PH_MPH		y_n	y_n	y_n	y_n	y_y	y_n	y_n	y_n	y_n	
Count (%)		161 (3.05)	4 (0.08)	9 (0.17)	13 (0.25)	188 (3.56)	31 (0.59)	12 (0.23)	1 (0.02)	11 (0.21)	
Cluster		rɪʃ	rʒ	lm	rd	rm	rt				
Exemple		marche	argent	filmer	regarde	ferme	parti				
Position(s)		n_y_y	n_y_y	n_y_y	n_y_y	n_y_y	n_y_y				
PH_MPH		y_n	y_n	y_n	y_y	y_n	y_y				
Count (%)		150 (2.84)	39 (0.74)	2 (0.04)	642 (12.17)	80 (1.52)	247 (4.68)				
Cluster				lt	rg	m					
Exemple				adulte	escargot	tourne					
Position(s)				n_n_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				2 (0.04)	40 (0.76)	140 (2.65)					
Cluster				rv	rn						
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lt	rg	m					
Exemple				adulte	escargot	tourne					
Position(s)				n_n_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				2 (0.04)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lt	rg	m					
Exemple				adulte	escargot	tourne					
Position(s)				n_n_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				2 (0.04)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
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Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
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Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
Exemple				servi	escargot	tourne					
Position(s)				n_y_y	n_y_n	n_y_y					
PH_MPH				y_n	y_n	y_n					
Count (%)				17 (0.32)	40 (0.76)	140 (2.65)					
Cluster				lv	rv	rn					
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PH_MPH				y_n	y_n	y_n					
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