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Abstract

Although French liaison is a recurrent theme in the study of adult phonology, its acquisition remains an unexplored subject. Moreover, frequent liaison consonant (LC) substitutions or insertions are well-known stereotypes of French "baby talk". However, their relationship with the acquisition of liaison and word segmentation has never been considered. Three types of data addressing these issues are presented. First, 665 such errors in the speech of a girl (from 2;1 to 3;6) are analysed. Second, an experiment was conducted (N=24, age mean = 3;8) with the aim of eliciting errors in real words. Third, a pseudo-word experiment with three age groups (age means: 3;5 (N=15), 4;6 (N=24), 5;8 (N=15)) investigated the segmentation of ambiguous sequences including pseudo-words. The main results are as follows: (1) certain LCs are encoded at the start of the right-hand word in the lexicon; (2) several alternating consonants can be encoded at this position; (3) at 3 years, the preference for an initial CV syllable is not a criterion for the segmentation of new words; however, at 4 and 5 years CV segmentations are avoided; (4) distributional regularities influence the segmentation of new words as of the age of 4 years; (5) between 3 and 4 years, the percentage of correct liaisons is correlated with age; (6) in those children aged 3-4 years who have the greatest mastery of liaisons, LC omission errors are more frequent and the frequency of /n/ in errors is reduced.

Acquisition of French Liaison and Related Child Errors

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The liaison in French is a recurrent theme in the study of adult phonology. From Schane's approach (1968), which followed Chomsky and Halle's (1968) framework of rule-based phonology, through to Tranel's recent proposals (in press ; 1996) conceived in the light of Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993), the modelling of the liaison has always proved to be an unavoidable test for any phonological theory. Moreover, the variable nature of certain liaison consonants has been the preferred object of research for corpus-based studies of phonological variation in adults (Ahmad unpublished, Lucci 1983, De Jong 1994).

We therefore have a good description of liaisons in adults and its functioning is modelled by a formal arsenal which illustrates the entire history and diversity of phonological theories. In contrast, its acquisition and usage in children remain unexplored. In addition, certain errors involving the addition or substitution of liaison consonants represent well-known stereotypes of French "baby talk". However, the link between these errors, the acquisition of the liaison and the problem of word segmentation has never been studied in depth.

These are the questions addressed by the present study. We shall start by presenting the functioning of liaisons at the factual level. We shall then summarize the debate concerning the lexical status of liaison consonants which lies at the heart of our child-related data. Finally, we shall present an analysis of a corpus of child errors and two experiments. The results show that, at an early age, liaison consonants do not occupy the lexical and syllabic position that is supposed in the vast majority of adult descriptions. They also reveal the first milestones on the way to the acquisition of the liaison at between 2 and 4 years.

1. The phenomenon of liaisons

In French-speaking adults, liaison consonants appear between two words in connected speech. A necessary condition is that the right-hand word starts with a vowel when spoken in isolation. In contrast, this consonant is never produced at the end of the first word when situated at the end of an utterance or when it precedes a word that starts with a consonant. Similarly, this consonant is never pronounced at the start of the second word when it is located at the beginning of an utterance. When this liaison consonant is produced, it generally forms a syllable with the vowel which follows it. For example, a /t/ is pronounced between *petit* and *écureuil* in the sequence *petit écureuil* ([ptitekyrœj] 'small squirrel') with the syllabification [pti.te.ky.rœj]. However, in adult speakers, this

/t/ is not pronounced in either *petit veau* 'small calf' ([ptivo]) or in *il est petit* 'he is small' ([ilepti]), or at the start of *Ecureuil !* 'Squirrel !'.

Not all consonants can act as liaison consonants. A study conducted by Boë and Tubach (1992) which analyzed 20 hours of adult speech has shown that /n/, /z/ and /t/ account for 99.7 % of produced liaisons (/n/: 18.9 %, /z/: 50.5%, /t/: 30.4 %). The remaining 0.3 % are shared between /p/, /R/ and /d/.

Finally, authors have traditionally subdivided liaison contexts into two categories, defined on the basis of morphosyntactic and lexical criteria: namely the contexts in which the liaison is obligatory and those where it is optional. When it is optional, the frequency of production is affected by a number of factors (Booij & De Jong, 1987, De Jong 1994, Malecot 1975) of a linguistic (length, category and frequency of the left-hand word, etc.) or extralinguistic nature (social status, speech style, etc.). In a review of five studies based on adult speech corpuses, Booij & De Jong (1987) concluded that a liaison is only truly obligatory in four contexts: after a determiner, between a pronoun and a verb, between a verb and a pronoun and in certain fixed expressions.

2.   The lexical status of liaison consonants

The presence of certain phonological or morphosyntactic contexts is a necessary condition for the definition of the position in which a liaison consonant judged to be acceptable by an adult *could* occur, irrespective of whether it is obligatory or optional. However, as Tranel (in press) notes, the presence of such contexts is not sufficient either to predict that a liaison is actually possible in this position or to select the liaison consonant - /z/, /n/ or /t/ - that might or should be used. Tranel (in press) comments that these two facts are determined by the left-hand word, *"as if (the liaison consonant) belonged to it"* (our translation). This leads him to believe that the two categories of questions that are asked concerning liaisons reflect its two different determining factors. Its conditioning by the context, which it shares with the epenthetic consonants, raises the question of the phonological and morphosyntactic definition of the sequences in which it is obligatory, optional or prohibited. Its lexical determination, shared with the consonants inherent in the words, raises the question of its status in the lexicon. Here, we shall address only the second of these sets of questions.

The analysis of the lexical status of the liaison consonants (from now on referred to as LC) raises two further questions: how can we represent their nature as alternating consonants and what is their lexical attachment?

To account for this alternation, certain phonologists consider the LC to be a floating consonant which possesses a phonetic content but is not anchored at the lexical level. It can therefore only be produced if it can be anchored within the context (Angoujard 1997, Encrevé 1988; Tranel in press). Other authors postulate the existence of two allomorphs: a long form with LC and a short form without LC (Perlmutter 1998, Long 1978). Since the gathered child data is

compatible with both these possibilities we shall not take a position in this debate.

The question concerning lexical attachment gives rise to three logically possible responses: the LC may be attached to the left-hand word at the lexical level, it may be attached to the right-hand word or it may be autonomous. Morin (in press) notes that almost all analyses have adopted the first solution: as the corresponding letter in the written form or as the former final etymological consonant from which it stems, the LC would "belong" to the left-hand word. However, his arguments cast some doubt on this postulate. Commenting that prenominal liaisons can be separated by a pause from the left-hand word, he suggests that it should be thought of as a prefix to the right-hand word. Thus, the /t/ in *petit écureuil* 'small squirrel' ([ptitekyrœj]) would be an inflectional marker which would receive the head of the NP *écureuil* when it is preceded by a complement[1]. The selection between the different liaison consonants would then depend on the morphological class to which the left-hand word belongs: *un* 'a/one', *mon* 'my', *ancien* 'old', etc. would belong to the same class and result in the selection of /n/; *petit* 'small', *grand* 'big' and *profond* 'deep' would result in the selection of /t/, etc.

If we consider that the affixes and the base form a single lexical item then Morin's analysis leads us to accept that the LC depends on the right-hand word. However, if instead we postulate that there are separate lexical entries for the base and the affixes then the LC is autonomous at the lexical level. However we conceive of the lexical configuration, the idea at the centre of Morin's proposals is that the prenominal LC is not lexically attached to the word that precedes it, since historical evolution has given rise to a resegmenting. The question is therefore to determine whether child data support Morin's proposals or whether their reinforce the commonly held position that considers the liaison as the final consonant of the lexical item that precedes it.

3.   An analysis of Sophie's errors

Errors involving liaison consonants are found frequently in French and are especially common in children. However, linguists have primarily concentrated on adult errors. On the basis of an analysis of approximately 200 errors, Desrochers (1994) concludes that they result from the conjunction of a variety of factors: lexicalisation of a specific item, morphologisation of an LC in a class (/z/ for all the class of adverbs), prefixation or suffixation of /z/ as a plural and /t/ as a verbal marker, planning error in the interaction between syntax and morphology. Child errors have never been analyzed for their own sake but have only been advanced in order to defend certain conceptions concerning adult phonology (Gaatone 1979, Klausenburger 1974). Our initial task was therefore to gather a sufficient corpus of errors in the speech of a small girl, Sophie, between the ages of 2;1 and 3;6.

The errors in Sophie's speech were recorded during interactions in a family context. Of these errors, 665 occurred between two words and involved either the phonemes /n/, /z/ and /t/, that is to say the most frequent liaisons, or /l/, a phoneme which often forms a syllable in combination with the initial vowel of a noun following the elision of the determiners *le* and *la*. If we compare these errors with the target adult production, two types can be identified:

- 276 cases of substitution: in a liaison context, in place of the liaison consonant we would expect in adults, Sophie produced a different consonant; for example, in the sequence *trois ours* 'three bears', we expect an obligatory liaison in the form of a /z/ in adults ([trwɑzurs]) but Sophie produces an /n/ ([trwɑ**n**uRs]).

- 389 cases of addition: in contexts where no liaison is expected in adults, Sophie adds an /n/ , a /z/, a /t/ or an /l/; for example, in the sequence *papa ours* 'daddy bear', we do not expect a liaison consonant for adults yet Sophie inserts an /n/, and produces [papa**n**uRs].

A rapid analysis of the errors leads us to four hypotheses, some of which are tested by the experiments presented below.

Hypothese 1: at the lexical level, the consonants involved in the errors are encoded at the onset of the right-hand word

The errors - like liaisons themselves - generally appear between two words: word1 and word2. Two arguments suggest that these consonants are associated with the onset of word2. The first argument is the simple fact that additions exist. By definition, an addition is the appearance of /z/, /n/, /t/ or /l/ in a word1_word2 context where no liaison appears in adults. Therefore Sophie could never have heard word1 followed by a liaison consonant. So, it is difficult to understand how she could associate this consonant with word1. In contrast, she might very well have heard word2 preceded by a liaison consonant or an /l/ forming a syllable with the initial vowel of the word. The second argument is the appearance of 41 addition errors without word1, in utterances starting with word2. For example, at 2;10, Sophie named the colour of the keys on her piano. She said *norange* instead of *orange*. These additions at the start of an utterance involved ten different words. They appeared at various ages between 2;1 and 3;1.

Hypothese 2: the consonant encoded at the start of a word is variable

We shall give two examples of this variability while limiting ourselves to the cases of addition errors. First, before the word *arbre* 'tree' (table 1), Sophie added an /n/ at 2;9.11 and 2;9.16. Then she added a /z/ three months later, then /n/ a month and a half later, then /l/ two weeks later. Second, before the word *orage* 'thunderstorm' (table 2), Sophie added /l/ at 2;4.17. Then she added /n/ two weeks later; and finally, two months later, she added /l/, /n/ and /z/ all on the same day.

Table 1 - Variability of additions in the context *X_arbre* 'tree'

Age	2;9.11	2;9;16	3;0.8	3;0.10	3;0.14	3;1.26	3;2.8	3;2.9
addition of...	/n/	/n/	/z/	/z/	/z/	/n/	/n/	/l/

Table 2 - Variability of additions in the context *X _orage* 'thunderstorm'

Age	2;4.17	2;10.24	from 2;11.7 to 2;11.13	3;0.4
addition of...	/l/	/l/	/n/ 5 times	/l/, /z/, /n/ 4 times

Hypothese 3: the consonant /n/ is "stronger" than the others

In table 3, it can be seen that /n/ is the consonant which most frequently replaces the others in the substitutions. In the additions, /n/ is the phoneme which is most often added.

Table 3 - Frequency of /l/, /n/, /t/ and /z/ in the substitutions and additions

	/l/	**/n/**	**/t/**	**/z/**	Chi square (theoretical balanced distribution for /l/, /n/, /t/, /z/)
Substitutions	13	188	30	45	Chi2 = 281, p < 0.001
Additions	37	226	32	94	Chi2 = 251, p < 0.001

Hypothese 4: the consonant encoded at the start of word 2 does not act as a morphological number marker.

Some authors have suggested that the /z/ liaison between a plural determiner and a noun acts as a plural prefix similar in morphological status to the English noun suffix -*s* (Morin & Kaye 1982). There are a number of French nouns that allow us to test this hypothesis with regard to Sophie's errors. In effect, in spoken French the plural form of nouns is identical to their singular form with a small number of exceptions. We shall confine ourselves to two, both of which start with a vowel: firstly, *oeuf* 'egg' which is pronounced [œf] in the singular and [ø] in the plural and, secondly, *oeil* 'eye' which is pronounced [œj] in the singular and [jø] in the plural. In addition, the plural determiners induce a /z/ liaison with the following noun while the singular determiners tend to induce an /n/ liaison. Sophie had therefore often heard [œf] and [œj] preceded by an /n/ liaison and [ø] and [jø] preceded by a /z/ liaison. If, in segmenting the input, she associates the liaison consonants with word2, then she should produce singular forms with the addition of /n/ and plural forms with the addition of /z/. And indeed in Table 4 it can be seen that /n/ is always added to the singular form and

/z/ to the plural form. In addition, the addition of /z/ has no morphological value. Of the 13 plural forms associated with a /z/, 9 have singular referents: a single egg or a single eye. For example, at 2;3.25, Sophie said [zjø] twice in a row while pointing one after the other at the two eyes in a portrait.

Table 4 - Addition of /n/ et /z/ before *œuf* 'egg' and *œil* 'eye'

Addition of →	/n/	/z/	/l/	/t/
Singular forms: [œf] and [œj]	9	0	1	0
Plural forms: [ø] and [jø]	0	13	0	0

4.   Experiment 1: inducing errors on real words

Experiment 1 was designed to test the hypothesis that variable LCs are encoded at the start of word2 at the age of 3-4 years. The logic underlying this experiment is as follows. If a word such as *ours* (bear) is preceded by different LCs in the child's mental lexicon, then hearing this word preceded by an /n/ liaison should activate the form /nuRrs/. As a result, errors of the type [denuRs] (*des nours*) instead of the correct form [dezuRs] should be more frequent after the child had heard *un ours* with an /n/ liaison. We therefore decided to compare an interference condition, in which the child produces *un ours* after hearing *des ours,* with a control condition, in which the child produces *des ours* without having been previously influenced. Even though this experiment was inspired by Morel's work (1994), it differs from it in at least one major respect. Unlike Morel, we introduced a control condition, which is the only way of deciding whether the expected errors occur by chance or result from the influence of the last LC heard.

Method - We used four word1 inducing liaison consonants in adults: two determiners, *un* with an /n/ liaison and *deux* with a /z/ liaison, and two adjectives, *petit* with a /t/ liaison, and *gros* with a /z/ liaison. In a picture naming task, each of these words was produced either in the obligatory liaison context, in front of four words2 with an initial vowel (avion 'plane', éléphant 'elephant', arbre 'tree', ours 'bear'), or in the non-liaison context, in front of four words2 with an initial consonant (*singe* 'monkey', *balai* 'brush', *ballon* 'ball', *cochon* 'pig'). Each of the thirty-two *word1_word2* sequences (see table 5) was produced while alternating a liaison and then a non-liaison context in two conditions. First, they were produced in a control condition by the simple naming of pictures. Then they were produced in the interference condition which was designed to induce errors. In this case, the experimenter said: *Sur cette image, il n'y a pas un ours* ([œ̃nuRs] with a correct /n/ liaison)*, mais...* 'On this picture there's not one bear, but...'. The child had to respond: *deux ours* 'two bears'. He or she therefore had to produce an obligatory /z/ liaison in [dɵzuRs] after having heard the /n/

liaison in [œ̃nuRs]. In all, there were four modes of interference which are presented in Table 6. Each mode was designed to produce one type of error.

Table 5 - Experiment 1: 32 sequences of type word1_word2

Word 2	
Liaison context: initial vowel	avion 'plane'
	éléphant 'elephant'
	arbre 'tree'
	ours 'bear'
Non-liaison context: initial consonant	singe 'monkey'
	balai 'brush'
	ballon 'ball'
	cochon 'pig'

Word 1		
Determiner	un 'a/one'	/n/ liaison
	deux 'two'	/z/ liaison
Adjective	petit 'small'	/t/ liaison
	gros 'big'	/z/ liaison

X

Table 6 - Experiment 1: the four modes of interference

Correct heard liaison		Correct liaison to be produced		Expected error	
un 'one/a' + N.	/n/	deux 'two' + N.	/z/	deux + /n/ + N.	/n/
deux 'two' + N.	/z/	un 'one/a' + N.	/n/	un + /z/ + N.	/z/
petit 'small' + N.	/t/	gros 'big' + N.	/z/	gros + /t/ + N.	/t/
gros 'big' + N.	/z/	petit 'small' + N.	/t/	petit + /z/ + N.	/z/

This experiment involved 24 subjects, 12 boys and 12 girls, aged from 3;0 to 4;5 (mean age = 3;8).

Results - Two analyses were conducted on the basis of these data: (1) a global analysis of the errors in order to consider in greater detail the question of the /n/ and (2) a comparison between the control condition and the interference condition in order to test the hypothesis formulated at the beginning of this section.

One initial fact is that the individual scores for correct liaisons are very variable. Given a maximum value of 32, the score varies between 2 and 31, depending on the subject, with a mean of 13. It also correlates with the age

calculated in months (rho = .41, p < 0.05). Out of 24 subjects, there are only 9 in whom /n/ is the consonant which most frequently replaces the others. However, these 9 subjects do not emerge at random. There is a negative correlation between the proportion of /n/'s in the errors and the correct liaison score (rho = -.48, p < 0.03). Finally, the experiment reveals a type of error which had not been observed in Sophie: namely, liaison omission errors. In places where we would expect an obligatory liaison - [dezurs] - there is no liaison at all but instead a sequence of two vowels: [deuRs]. These omissions are frequent and represent 19 % of occurrences. There is also a positive correlation between the number of correct liaisons and the number of omission errors as a proportion of total errors (rho = .625, p < 0.003). This suggests that the children who best master liaisons have a tendency to inhibit the consonant situated at the start of word2.

We next move on to the verification of the hypothesis of the influence of the last liaison to be heard. The variances are non-uniform despite the application of arc-sine or log transformations. We therefore used a nonparametrical statistical test.

If all four interference modes are considered together, the expected errors were more numerous when the children had just heard a liaison inducing these errors. Out of a maximum possible 16 expected errors, the subjects produced 1.5 on average in the control condition and 3.5 in the interference condition (Wilcoxon: z = -3.96, p < 0.0001). More precisely, 22 subjects had different expected error scores in the two conditions. Of these, twenty-one had a higher score when they had just heard the interference liaison. If we now consider the four interference modes separately, the results can be seen in Table 7. In each of the two morphosyntactic contexts, only the mean scores which are linked by a line are significantly different in the Wilcoxon test (p ≤ 0.05).

Table 7 - Experiment 1: expected error scores in the four interference modes

max. = 4	Determiner + noun context		Adjective + noun context	
Heard liaison	deux+/z/+N.	un+/n/+N.	petit+/t/+adj.	gros+/z/+adj.
Target liaison	un+/n/+N.	deux+/z/+N.	gros+/z/+adj.	petit+/t/+adj.
Expected error	un+/z/+N.	deux+/n/+N.	gros+/t/+adj.	petit+/z/+adj.
Substitution	/z/ replaces /n/	/n/ replaces /z/	/t/ replaces /z/	/z/ replaces /t/
Control condition	0.2	0.75	0.12	0.42
Interference condition	1.4	1.08	0.37	1.04

We can interpret the result pattern as follows. In three of the interference modes, hearing a liaison prior to production increases the number of expected

errors, but not when the expected error is of the type "/n/ replaces /z/". In the "determiner + noun" context, these errors of the type "/n/ replaces /z/" are observed even without the effect of the heard liaison: even in the control condition, in which no liaison is heard before production, they are more frequent than the /z/ errors in the sequence "*un* + noun". The results are compatible with the initial hypothesis. Different alternating consonants are encoded at the start of word2. Hearing a liaison before word2 activates one or other of these consonants which then becomes available for production. Unlike the /z/ or /t/ forms, the /n/ forms are available for production even if not heard in advance. This again indicates the special status of /n/. Experiment 2 was designed to attempt to unravel the mystery of /n/.

5.   Experiment 2: the segmentation of new words

When adults hear a sequence such as /lœRzɛl/, they cannot decide whether this should be interpreted as *leurs ailes* 'their wings' with a /z/ liaison, or as *leur zèle* 'their zeal' with a /z/ at the onset of the noun following the determiner. Moreover, this ambiguity slows down lexical access and seems to result from an identical duration of the liaison consonant and the initial consonant (Yersin-Besson & Grosjean 1996). If children experience the same lexical indecision, then they will have difficulty segmenting new words in a sequence containing /z/, /n/ or /t/ at the border between two lexical units. More precisely, they will respect the borders between syllables at the expense of the borders between morphemes (Peters 1985).

Of the many constraints which are likely to influence segmentation, we shall consider just two. Firstly, children might be expected to perform segmentation by aligning the word with frequent syllabic structures (Peters 1985). Our initial hypothesis is that they should therefore favour CV syllables in new words and will therefore tend to consider /z/, /n/ or /t/ as initial consonants. Secondly, computer simulations show that phonotactic and distributional regularities are useful for segmenting continuous speech into lexical units (Brent & Cartwright 1997), and that they are effectively used by children (Aslin, Saffran & Newport 1999). In the French lexicon, the following regularities can be observed (table 8). Whatever the vowel V, more words start with /nV/ than with /zV/: /n/ is therefore a more likely segmentation point than /z/. Our second hypothesis is therefore that children will process /n/ as the initial consonant more frequently than /z/, thus explaining the special strength of /n/ observed in the errors.

Table 8 - /nV/ and /zV/ word-starts in the French lexicon (Content, Mousty & Radeau 1990)

V	ɑ	a	ã	e	ɛ	i	ɛ̃	o	ɔ	ɔ̃	u	y
# nV	2	80	3	60	17	24	6	10	64	15	16	26
# zV	0	1	0	10	3	8	2	3	6	0	0	0

Method - The use of pseudo-words is a simple way of simulating a child's encounter with a little known or unknown word. Ten pseudo-words were therefore created on the basis of real words, either by deleting or substituting one of the first three phonemes. These pseudo-words were presented to the children in a picture naming task involving imaginary animals, in a random order. They were mixed with twenty true words. Among these, ten started with a vowel and ten with a consonant other than /n/ or /z/. The naming task required either the transition from a singular determiner with an /n/ liaison to a plural determiner with a /z/ liaison, or the opposite transition. For example, the experimenter showed the child a picture of an imaginary animal and said: *Voici* [œ̃nuRmil] (this is *un (n)ourmil*). Neither [nurmil], nor [zuRmil], nor [uRmil] are French words. The child then named a picture containing a number of imaginary animals of the same type. He or she said either [denuRmil] (*des nourmils*), in which case we considered that the /n/ of [œ̃nuRmil] had been processed as an initial consonant (CV response); or the child said [dezuRmil] (*des ourmils,* with a /z/ liaison), in which case we considered that the /n/ had been processed as a liaison consonant. Three age groups took part in the experiment (see Table 9).

Table 9 - Experiment 2: three age groups

	Mean age	Age range	Number
Group 1	3;5	[3;2 - 3;11]	15
Group 2	4;6	[4;2 - 4;11]	24
Group 3	5;8	[5;1 - 5;10]	15

Results - To test the first hypothesis, we calculated the number of CV responses for pseudo-words and words starting with a vowel for each participant. Since there were 10 items (5 transitions from *un* to *des* and 5 transitions from *des* to *un*), random responding should lead to 5 CV responses. A t test can be used to decide whether the CV response scores are different from this random value (see Table 10). In the youngest subjects, the CV scores for words and pseudo-words are not significantly different from the random value 5. In the other two groups, there are <u>fewer</u> CV responses than would be predicted by random responding. This result is validated for real words starting with a vowel, which was expected, as well as for the pseudo-words, which is more surprising. Moreover, at all ages, we observe a correlation between the CV response scores for words and the CV response scores for pseudo-words (Group 1, Rho = .94, p = .0004; Group 2, Rho = .67, p = .0013, Group 3, Rho = .69 , p = .009). The same mechanism is therefore responsible for the processing of the two types of item.

Table 10 - Experiment 1: CV responses (comparison with random value 5)

	Pseudo-words		Vowel-initial words	
	Mean	T test (theoretical mean = 5)	Mean	T test (theoretical mean = 5)
Group 1 [3;2 - 3;11]	5.7	t = .75 (p = .46) n.s.	3.9	t = -1.3 n.s.
Group 2 [4;2 - 4;11]	2.8	t = - 5.2 (p < .0001)	.8	t = - 13 (p < .0001)
Group 3 [5;1 - 5;10]	3.4	t = -3.3 (p = .0047)	.4	t = - 28 (p < .0001)

These results do not therefore confirm the first hypothesis. CV segmentation of new words is still possible at age 3-4 years, although it is not the preferred processing mode. As of 4 years, it is avoided and ambiguous consonants are processed as liaison consonants. However, it is possible that this result could be challenged by a study involving a younger age group in which the CV patterns might be more salient. Such a study should also consider more precisely the frequency of the consonants /n/ and /z/ in all positions: LC, initial, final, medial.

To test the second hypothesis, we compared the number of CV responses involving /n/ in the transition from *un* to *des* and the number of CV responses involving /z/ in the transition from *des* to *un* for pseudo-words. Clearly, the lexical regularities predict that /n/ will be processed more often as the word onset than /z/. The data fulfil the conditions of validity of the anova.

The age effect ($F_{(2-51)}$= 6.1, p <.005), the consonant effect (/n/ as initial *vs* /z/ as initial, $F_{(1-51)}$= 13.4, p <.005) and the age*consonant interaction ($F_{(2-51)}$= 6.2, p <.005) are significant (see the means and the standard deviations in table 11) . The analysis of the interaction is as follows. In group 1, at Sophie's age and that of the subjects of experiment 1, the /n/ is not processed as an initial consonant any more frequently than /z/ ($F_{(1-51)}$ = 1.24, p > .25). However, this tendency appears in group 2 ($F_{(1-51)}$= 16.6, p <.001) and persists in group 3 ($F_{(1-51)}$ = 7.02, p < 0.025). There is no age-related development of the processing of the /n/. The processing of /z/ as initial consonant develops with age. The children in groups 2 and 3 process /z/ as an initial consonant less frequently than in group 1. The difference between 3.1 and 0.6 is significant ($F_{(1-51)}$ = 23.8, p < .001), as is the difference between 3.1 and 1.1 ($F_{(1-51)}$ = 13.1, p <.005), while the difference between 0.6 and 1.1 is not ($F_{(1-51)}$ = .7, p > .25). In short, children seem to benefit from these lexical regularities. More particularly, they seem to use the fact that /z/ almost never appears at the start of words. However, this ability appears at too late an age to make it possible to explain the strength of /n/ in the errors at around 3 years and 6 months, or even earlier.

Table 11 - Experiment 2: /n/ vs /z/ are processed as the initial consonants

Max. = 5	/z/ is processed as initial consonant	/n/ is processed as initial consonant
Group 1 [3;2 - 3;11]	3.1 (2.2)	2.6 (1.9)
Group 2 [4;2 - 4;11]	0.6 (1.1)	2.2 (1.4)
Group 3 [5;1 - 5;10]	1.1 (1.5)	2.3 (1.7)

5. Discussion

To summarize, the analysis of the errors and the two experiments reveal the following milestones in the acquisition of liaisons between 2 and 4 years: (a) the LCs, or at least some of them, are encoded at the start of word2 in the lexicon; (b) several alternating consonants can be encoded at this position; among these, the /n/ is the most readily available and the /z/ does not have the morphological status of a plural prefix; (c) at 3 years, the preference for an initial CV syllable is not a criterion for the segmentation of new words and at 4 and 5 years, CV segmentations are actually avoided; (d) the distributional regularities (/n/ more frequent than /z/ in initial position) influence the segmentation of new words at 4 and 5 years; since this influence is absent at 3 years, it cannot explain the special availability of /n/; (e) listening to a /z/ or a /t/ liaison before production increases the proportions of /z/ and /t/ in the errors; (f) between 3 and 4 years, the percentage of correct liaisons is extremely varied and correlated with age; (g) in those children aged 3-4 years who have the greatest mastery of liaisons, LC omission errors are more frequent and the frequency of /n/ in errors is reduced.

On the basis of these facts, it is possible to outline two potential developmental scenarios. In both cases, the first stage is the same. In the input, the LCs (and the elided /l/ of the articles) form a syllable with the following word. Children would therefore start to encode them at the start of word2. Even if the segmentation of new words does not favour CV syllables at 3 years, it is still possible that this tendency may be efficient at an earlier age. At the same time, it is possible that an explanation other than the effect of distributional regularities might account for the availability of /n/. In a number of corpus-based studies of adults (Malécot 1975), it has been observed that /n/ liaisons are less frequent than /z/ or /t/ liaisons. However, the speakers in question are often communications professionals (journalists, etc.) recorded in formal situations. If we consider a more diverse range of speakers acting within their familiar environment, the frequencies of /n/ and /z/ are higher than that of /t/ (Ahmad, unpublished)[2]. Children's everyday environment primarily brings them into contact with obligatory /z/ or /n/ prenominal liaisons. However, /z/ appears later than /n/ in the phonological inventory of French children (Vinter to appear). The availability of /n/ would therefore appear to result from the interaction of the frequency factor - which penalizes /t/ - and the order of acquisition - which penalizes /z/.

The next stage in this developmental scenario depends on the lexical attachment of LCs that we consider to be operational in adults. If we accept Morin's (in press) conception of liaisons in adults (i.e. the LCs are inflectional prefixes of word2), then the next step in acquisition consists of learning to select one or other of the consonants as a function of the class of word1. If, however, we accept the traditional position which attaches the LC to the end of word1, then the next stage of acquisition necessarily involves a complete restructuring of the phonological representations, with the LC having to be detached from word2 in order to become gradually attached to word1 (Morel 1994). The fact that the LCs are encoded at an early age at the start of word2 clearly argues in favour of Morin's theory. However, the existence of omission errors and their positive correlation with mastery of liaisons rather suggests that a late inhibitory process applies to the LC encoded at the start of word2. Finally, only Klausenburger's position (1974) is weakened by our data, which are incompatible with the idea that children initially omit the LCs and only later add them to their lexical representations.

Endnotes

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1. Morin (in press) gives other examples of such cases which are referred to as status inflection.
2. In effect, the optional liaisons which are often produced in formal situations involve /t/ or /z/, whereas the /n/ liaisons which are normally obligatory are present in all situations.

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